

The University of Chicago

RELATIONSHIPS BETWEEN MENTAL AND PHYSICAL GROWTH

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CHAPTER I

INTRODUCTION

General Aspects of the Problem

Since the publication, in 1893, of Porter's pioneer investigation,¹ many research studies have been conducted with the purpose of determining the relation of the intelligence of school children to various indices of physical growth. These studies have differed widely among themselves in the criteria of intelligence employed, in techniques of investigation, and in methods of analysis. It is not surprising, therefore, that the resulting data are not in entire agreement. However, the general trend of results indicates that the mental and physical measurements of children are to some extent positively related. Some of the early studies have been widely quoted as showing a high degree of positive relationship between intelligence and physical traits. More critical appraisal of the data within recent years has led students of child development to believe that the correlation is decidedly lower than Porter,² Crampton,³ Baldwin,⁴ and other early investigators of the problem inferred from their results. The conclusion generally accepted at the present time is that the correlation between mental and physical status during childhood is, in general, positive but low.

Little inquiry has been made into the causal factors involved in this relationship. Some writers have suggested that its basis may be largely in individual differences in economic-social status, and that a socially homogeneous group would probably show negligible correlation between mental and physical status. This hypothesis was offered recently by Paterson in a critical review of studies which have dealt with the relation of the mental to the physical.⁵ Whipple, in 1914, presented a very different type of clue to the investigation of the problem. His statement follows:

The apparent correlation between height and mental ability raises an important question which reappears whenever we discuss the correlation between any physical trait, e.g., weight, strength, vital capacity, etc., and mental ability. The trend of evidence is to the effect that all such correlations, where found, are largely explicable as phenomena of growth, i.e., as correlations with relative maturity. . . . This makes intelligible the fact that, in general, the positiveness of all such correlations lessens with age, and that many of them, indeed, become difficult or impossible of demonstration in adults.⁶

¹ William Townsend Porter, "The Physical Basis of Precocity and Dullness," Transactions of the Academy of Science of St. Louis, Vol. VI, No. 7 (1893), 161-181.

² Ibid.

³ C. Ward Crampton, "The Influence of Physiological Age upon Scholarship," Psychological Clinic, I (1907), 115-120. Ibid., "Anatomical or Physiological Age versus Chronological Age," Pedagogical Seminary, XV (1908), 230-237. Ibid., "Physiological Age-A Fundamental Principle," American Physical Education Review, XIII (1908), 141-154, 214-227, 268-283, 345-358.

⁴ Bird T. Baldwin, The Physical Growth of Children from Birth to Maturity. University of Iowa Studies in Child Welfare, Vol. I, No. 1, 188-236. Iowa City, Iowa: The University of Iowa Press, 1921. Ibid., "The Relation between Mental and Physical Growth," Journal of Educational Psychology, XIII (1922), 193-203. Ibid., "Methods of Selecting Superior or Gifted Children," Twenty-third Yearbook of the National Society for the Study of Education, Part I, pp. 25-47. Bloomington, Illinois: Public School Publishing Co., 1924.

⁵ Donald G. Paterson, Physique and Intellect. New York: The Century Co., 1930. Pp. xxvii + 304.

⁶ Guy Montrose Whipple, Manual of Mental and Physical Tests, Part I, p. 71. Baltimore: Warwick and York, 1914.

Professor Frank N. Freeman, in 1920, raised a question similar to that of Whipple, and offered a definite suggestion for the study of the problem of relationships between mental and physical growth. In a protest against the customary identification of mental maturity with superiority in intellectual capacity, Professor Freeman stated that the only means of distinguishing between the level of capacity which the individual will ultimately reach and the rate of maturing of that capacity is through repeated measurements up to maturity.⁷ There is implied in this statement the possibility of distinguishing between brightness and precocity--that is, between the relative level of the road which the child travels and his rate of progress along that road. Professor Freeman has long maintained that there may be such a distinction, and that only through the repetition of both mental and physical examinations is it possible to determine whether the mental and physical relationship which exists during childhood is permanent or merely a matter of correlation in rate of mental and physical growth.

Purpose of the Present Study

The present study was planned with the purpose of making a more thorough analysis of relationships between mental and physical growth than has usually been possible.⁸ Interest has centered in the determination of the extent to which rate of mental development is correlated with rate of physical growth in the repeated measurements of children. It is understood that correlation in rate of mental and physical growth may involve a complexity of factors. For example, if a relationship does exist, it may be general, involving the entire period of development rather than a relatively small phase of the period; or the relationship may be limited to some form of correlation, either positive or negative, between fluctuations in rate of mental and physical growth.

The Data

The subjects.— There were employed in the investigation 637 subjects: 179 boys and 178 girls, pupils of ages eight through seventeen in the Laboratory Schools of the University of Chicago; 140 young women, students in a small Southern college; and 140 university men.

The character of the populations in an investigation of this type is of considerable importance. It is significant that the pupils in the Laboratory Schools are unusually homogeneous with respect to economic and cultural status. As members of a highly selective private school, they are, with few exceptions, well-nourished, carefully trained, healthy, energetic children. There is less homogeneity in race; approximately twenty per cent of each sex are Jewish. The non-Jewish children are, in the main, from a mixture of Northern European races. In intelligence the Laboratory-School children are decidedly above the general average, but there is considerable variability. The mean Stanford-Binet I.Q. for the boys used in the study is 115.8, with standard deviation of 13.5; for the girls, the mean is 116.4, with standard deviation of 12.1.

The data for college students form a supplementary part of the study. In selecting the adult subjects, it was intended to duplicate as nearly as possible the type of population found in the Laboratory Schools, in order that a cross section at an upper level might be compared with the results from the study of less mature subjects. Duplication was achieved to a

⁷ Unpublished lectures, 1920.

⁸ The data reported in earlier studies have in nearly all instances been collected through the method of random sampling. The writer knows of no completed investigation, previous to the present one, which has assembled its material from the repeated mental and physical examinations of a large number of subjects over a long period of time. Mass studies of the association between mental and physical traits fail to answer the questions which are raised in the present treatise.

large extent with the young men who served as subjects. The young women selected differ significantly from the girls of the Laboratory Schools. Description of the adult subjects is given in Chapter VII, in connection with the statement and interpretation of the results of this phase of the investigation.

The records for children.— The data for the children were taken from the permanent records of the Laboratory Schools. The physical data selected consist of measures of standing and sitting height,⁹ weight,¹⁰ carpal development (both the total ossification and the ossification ratio),¹¹ chest girth,¹² lung capacity (for boys),¹³ and records of pubescence.¹⁴ Every pupil in the Laboratory Schools is given an elaborate physical examination close to his birthday. The measurements are usually made within the birthday week. Deviations within ± 15 days were accepted in the selection of data. The physical examinations are made or supervised by school physicians skilled in anthropometry. All conditions of measurement are standard. The physical traits selected for the investigation are the time-honored indices of physical maturing which the early studies proclaimed as highly correlated with intelligence.

The mental-test data used in the investigation have been collected during a period of eleven years by the staff psychologists of the Laboratory Schools. The test of intelligence employed was arranged by Professor Freeman in 1921, and a testing program was put into operation at the beginning of the autumn quarter of that year. As in the physical examinations, measurements were made on, or within a few days of, the subject's birthday, and the same subjects were tested from year to year. The intelligence test is an individual point scale which consists of four language tests: verbal analogies, word opposites, sentence completion, and the Terman vocabulary test. There is no time limit to any part of the test. This fact probably accounts in part for the very low practice effect found with repeated testing. A monograph by Professor Freeman¹⁵ gives the content of the tests, and includes a very detailed description of the organization and administration of the testing program. Professor Freeman shows that the validity

⁹ Height is measured in millimeters and translated into inches. The records give the measures to the tenth of an inch.

¹⁰ Weight is measured in kilograms and translated into pounds. The records give the measures to the tenth of a pound.

¹¹ The ossification ratio is the ratio of the total skiagraphic area of the ossified carpal bones and epiphyses of the radius and ulna to the area of a quadrilateral formed by connecting points as follows: the upper and outer point of the ulnar shaft, to the nearest point on the base of the fifth metacarpal, to the nearest point on the epiphysis on the base of the first metacarpal, to the upper and outer point on the radius.

Detailed description of the technique employed in making the radiographs and in computing the measures of carpal development is given by Carter (Thomas Milton Carter, "A Study of Radiographs of the Bones of the Wrist as a Means of Determining Anatomical Age," pp. 19-58. Unpublished Doctor's thesis, Dept. of Education, University of Chicago, 1923).

¹² Three measures of chest girth were available: inflated, normal, and deflated. Normal girth was selected because study of losses from age to age in each of the measures indicated that it was the most reliable of the three.

¹³ The measurements of lung capacity were taken on a wet spirometer manufactured by the Narragansett Machine Co., Providence, Rhode Island. Measures of lung capacity were not available for all the girls used as subjects. Hence this index of physical development was omitted in the study of girls.

¹⁴ Girls are said to have reached pubescence at the time of occurrence of the first menstruation. Two indices of physiological maturing are used in the case of boys: pubes and the appearance of axillary hair. The school physician's records for boys show the stage of development in each of these indices at the time of every birthday examination made. For the boys in the present study, axillary hair appears, on the average, approximately one year later than pubic hair. The percentages follow: appearing within the same year, 5.3; one year later, 68.4; two years later, 24.6; three years later, 1.7.

¹⁵ Frank N. Freeman and Charles D. Flory, "A Study of Mental Growth by Repeated Tests." (Monograph to be published by Society for Research in Child Development).

and reliability of the intelligence test are sufficiently high to justify conclusions based upon repeated measurements with the same subjects. He also justifies in this monograph the construction of the mental-growth curve upon the basis of the units of the test.

Each of the 357 subjects selected from the Laboratory-School records has had at least two consecutive birthday examinations in the physical traits listed and in the intelligence test described in the foregoing paragraph. The average number of consecutive birthday examinations is five, for both boys and girls. The highest number is eight. Table I of the Appendix shows the distribution of the examinations with regard to age of subjects and number of consecutive measurements.¹⁶

Two features of the data for the Laboratory-School subjects make the present investigation especially significant: (1) the experimental control of the factor of chronological age, and (2) the retesting of a large number of subjects for a considerable period of time. It is also worthy of note that the mental and physical examinations were made by specialists who had no interest in the problem of correlating the two sets of data.

Data for adults.— The mental testing of the 280 college students was done by the writer. The intelligence test administered was the same as that used with the Laboratory-School subjects. The physical measurements were made in nearly all cases by the physical director in the college or university. The conditions of measuring were standard, as with the children. Only measures of standing height and weight were made for the adults. Records of age at onset of pubescence were secured for the young women. A more detailed account of the data for the college students appears in Chapter VII.

Specific Phases of the Investigation

The character of the data assembled for this study makes possible consideration of the following specific problems: What is the degree of correlation between the mental and physical measures employed when the factor of chronological age is controlled experimentally? Do mental and physical relationships tend to decrease with approach to maturity? Are increments in intelligence-test scores correlated with increments in the various physical traits selected? Do growth curves reveal any concomitance in mental and physical development? To what extent do periods of acceleration or retardation in the mental-growth curves coincide with similar phases in the curves of physical growth? Do children different in level of mental capacity differ also in rate of mental and physical maturing? It has frequently been advocated that the advent of puberty has a perceptible influence on mental development. Is this effect shown in the mental-growth curves of individuals or of groups homogeneous in age of physiological maturing? Are sex differences in rate of physical maturing reflected in the curves of mental growth? When the sexes are considered independently, is there any relation between physiological maturing and mental development? To what extent do relationships demonstrated during the period of development appear at maturity?

Data bearing upon the foregoing problems appear in Chapters III-VII. Chapter III shows the results of the application of direct correlation technique¹⁷ to the birthday measurements of the pupils in the Laboratory Schools. Chapter IV presents an analysis of mental- and physical-growth curves for groups of subjects. The question of concomitance in rate of

¹⁶ Professor Freeman's study (op. cit.) is based upon data for a larger number of subjects. The writer was limited to those subjects for whom physical, as well as intelligence, records were complete.

¹⁷ The Pearson product-moment correlation coefficients are given in all cases where correlation has been computed.

mental and physical growth is approached from another point of view in Chapter V, through comparison of curves of variability in mental and physical traits. In this chapter, the problem of relation between rate and level of the growth curves, mental and physical, is also considered. Chapter VI deals with the various aspects of the problem of pubescence in relation to mental growth. The supplementary study of the mental and physical measurements of adult subjects appears in Chapter VII.

CHAPTER II

PREVIOUS INVESTIGATIONS OF THE RELATIONSHIP OF THE INTELLIGENCE OF CHILDREN TO CERTAIN PHYSICAL TRAITS

Research relative to the general problem of correlation between the mental and physical status of children has been very extensive and has developed along several lines. A recent publication¹ reviews investigations in this field so fully and critically that only a brief summary of studies closely related to the present one in the selection of the criteria of physical growth is presented here.

The Correlation of Intelligence with Height and Weight

The earliest studies of height and weight in relation to intelligence were concerned with the comparison of feeble-minded with normal children of the same ages, and were based upon averages. Tarbell, in 1881, found from his investigation of feeble-minded children in a Boston institution, that the feeble-minded throughout their period of growth were about two inches shorter and nine pounds lighter than normal children of the same age.² Tarbell compared his data with those obtained by Bowditch from his measurements of Boston school children. Shuttleworth reported similar results from his comparison of the heights and weights of feeble-minded children in three English institutions with the norms of the general population.³ The conclusions of these early studies have been repeated with very little variation by later writers who have measured feeble-minded children, notably by Wylie,⁴ Goddard,⁵ Mead,⁶ and Doll.⁷ Doll supplemented his study of averages with a report of coefficients of correlation between mental age and measurements of standing height, sitting height, and weight. The coefficients, with correction made for chronological age, are in all cases positive, and range from .23 (weight and mental age of 333 boys) to .47 (sitting height and mental age of 140 girls).⁸ The results of an investigation by Norsworthy differ somewhat from the general trend in that she found the mental defectives studied, only slightly inferior to normal children in physical measurements.⁹ Paterson, in his critical review of these reports

¹ Donald G. Paterson, Physique and Intellect. New York: The Century Co., 1930. Pp. xxvii + 304.

² G. G. Tarbell, "On the Height, Weight, and Relative Growth of Normal and Feeble-minded Children," Proceedings of the Association of Medical Officers of the American Institutions for Idiotic and Feeble-minded Persons, 1876-1886, pp. 188-89.

³ G. E. Shuttleworth, "The Health and Development of Idiots Compared with Mentally Sound Children of the Same Age," Proceedings of the Association of Medical Officers of the American Institutions for Idiotic and Feeble-minded Persons, 1876-1886, pp. 315-22.

⁴ A. R. T. Wylie, "Investigation Concerning the Height and Weight of Feeble-minded Children," Journal of Psycho-Asthenics, IV (1899), 47-57. Ibid., "Contribution to the Study of the Growth of the Feeble-minded in Height and Weight," Journal of Psycho-Asthenics, VIII (1903), 1-7.

⁵ H. H. Goddard, "The Height and Weight of Feeble-minded Children in American Institutions," Journal of Nervous and Mental Diseases, XXXIX (1912), 217-35.

⁶ Cyrus D. Mead, "Height and Weight of Children in Relation to General Intelligence," Pedagogical Seminary, XXI (1914), 394-406. Ibid., The Relations of General Intelligence to Certain Mental and Physical Traits. Teachers College Contributions to Education, No. 76. New York: Teachers College, Columbia University, 1916. Pp. 118.

⁷ E. A. Doll, Anthropometry as an Aid to Mental Diagnosis. Publications of the Training School at Vineland, New Jersey, No. 8 (1916). Pp. 92.

⁸ Ibid., p. 47.

⁹ Naomi Norsworthy, The Psychology of Mentally Deficient Children. Archives of Psychology, I (1906). Pp. iii + 112. Ibid., "Suggestions Concerning the Psychology of Mentally Deficient Children," Journal of Psycho-Asthenics, XII (1907), 3-17.

of institutional cases, calls attention to the importance of carefully defining and delimiting the norms to be used as the bases of such comparative studies; to the advisability of inquiring into the prevalence of pathological varieties of feeble-mindedness, such as cretinism, in the populations studied; and to the possible rôle played by the factor of selection.¹⁰

Two investigations of the height and weight of dull and retarded school children have been reported in recent years. Dayton presents his data for 3,553 retarded children in averages which suggest a slight positive relation between mental-test scores and physical status.¹¹ A report by Wheeler is based upon data collected through the Harvard Growth Study. This investigation was conducted with attention to the race of the subjects, and with unusual care in regard to other factors. Children were selected from the public schools by the use of group intelligence tests. The dull children (those with I.Q.'s below 90) were compared with children of I.Q.'s between 90 and 110 with respect to standing height, sternal height, sitting height, leg length, trunk length, weight, and iliac width. The physical differences between the two groups were found to be "comparatively small but fairly consistent" for the ages studied--from the age of six through eleven. Dull children were below normal in all measures of physical growth except in trunk length, and in iliac measure at the age of six for girls.¹²

The trend of investigations of total school populations is, in the main, in agreement with the comparative studies of defective and normal children. Porter,¹³ using age-grade location as the criterion of ability, found that the precocious children of a given age were both taller and heavier than the mean, while the dull ones were lighter. Porter's method has been followed by Beyer,¹⁴ Christopher,¹⁵ Smedley,¹⁶ De Busk,¹⁷ and Pyle,¹⁸ with conclusions very similar to those of Porter. Criticism of the technique employed by these workers has been directed to the criterion used and to the statistical procedure. Averages alone do not give an exact measure of the amount of relationship which exists. Three investigators, Gilbert,¹⁹ West,²⁰ and MacDonald,²¹ likewise used the method of averages but adopted a different criterion of ability, namely, teachers' ratings. The results of their studies are practically negative in regard to mental and physical

¹⁰ Op. cit., pp. 52-66.

¹¹ N. A. Dayton, "Height, Weight, and Intelligence Relationships in 3,553 Retarded School Children," New England Journal of Medicine, 199 (1928), 934-38.

¹² L. R. Wheeler, "A Comparative Study of the Physical Growth of Dull Children," Journal of Educational Research, XX (1929), 273-82.

¹³ William Townsend Porter, "The Physical Basis of Precocity and Dullness," Transactions of the Academy of Science of St. Louis, Vol. VI, No. 7 (1893), 161-81.

¹⁴ Henry G. Beyer, M. D., "The Relation between Physique and Mental Work," American Physical Education Review, V (1900), 149-60.

¹⁵ W. S. Christopher, M. D., "Measurements of Chicago School Children," Journal of the American Medical Association, XXXV (1900), 683-87.

¹⁶ Fred W. Smedley, "Child Study in Chicago," Report of the United States Commissioner of Education, Vol. I (1902), 1095-1115.

¹⁷ B. W. De Busk, "Height, Weight, Vital Capacity and Retardation," Pedagogical Seminary, XX (1913), 89-92.

¹⁸ W. H. Pyle, "The Relation of Mental to Physical Development," Journal of Delinquency, III (1918), 210-12.

¹⁹ J. Allen Gilbert, "Researches on the Mental and Physical Development of School Children," Yale Psychological Laboratory Studies, II (1894), 40-100.

²⁰ G. M. West, "Observations on the Relation of Physical Development to Intellectual Ability," Science, New Series, IV (1896), 156-59.

²¹ Arthur MacDonald, "Experimental Study of Children, Including Anthropometrical and Psychophysical Measurements of Washington School Children," Reprint of Chapters XXI and XXV from Report of the United States Commissioner of Education, (1897-1898). Washington, D. C.: Government Printing Office, 1899.

relationship. MacDonald concluded that his results were in harmony with those of Porter, but his data show no consistent trend. It is significant that those investigations in which teachers' judgments have been used as a measure of intelligence have resulted in negative findings in regard to correlation between height and the estimate of mental ability. Teachers' judgments applied to class groups probably involve overestimation of the dull and retarded pupils, due to the fact that they are compared with younger pupils who have had less amount of schooling. Kempf and Collins,²² in a comparatively recent study of the averages in height and weight for each of three I.Q. groups, have reported data in harmony with Porter's. A more exact correlation technique has been employed in most of the recent investigations of the relation between mental-test scores and measures of height and weight. Baldwin, using the method of partial correlation to eliminate the variable of chronological age, found for 49 girls coefficients of $+ .53$ between height and mental age and $- .15$ between weight and mental age.²³ Studies of larger numbers of children by Murdock and Sullivan,²⁴ Gates,²⁵ and the writer²⁶ agree in showing low positive correlation between each of these two physical measures and mental-test scores. The highest coefficients reported in these studies are from the writer's work with girls in the Elementary School of the University of Chicago. For 120 girls, ages six through twelve, the partial correlation for constant age was $+ .34 \pm .05$ between height and Stanford-Binet mental age, and $+ .39 \pm .05$ between weight and the same criterion of ability.

The results of studies of the physical status of gifted children are in agreement with the general trend of a low positive relationship between intelligence and size. Hollingworth has given comparative data regarding the height and weight of children above 135 Stanford-Binet I.Q. The children were found to be significantly superior in size as a group to less gifted children.²⁷ Terman has presented evidence of slight positive correlation of physical with mental measures even in a very highly selected group of children. The coefficients of correlation between mental age and measures of height and weight of 397 "children of genius," ages ten through thirteen, are at nearly every age positive for each sex group. The number of subjects, divided into different age groups, is too small for the results to be consistent.²⁸

Carpal Development and Intelligence

The results secured from the correlation of measures of wrist-bone development with mental age are somewhat less consistent than the data report-

²² Grover A. Kempf and Selwyn D. Collins, "A Study of the Relation between Mental and Physical Status of Children in Two Counties of Illinois," United States Public Health Reports, Vol. XLIV, No. 29 (1929), 1743-84.

²³ Bird T. Baldwin, "The Relation between Mental and Physical Growth," Journal of Educational Psychology, XIII (1922), 193-203; Bird T. Baldwin and Lorle I. Stecher, Mental Growth Curve of Normal and Superior Children Studied by Means of Consecutive Intelligence Examinations. University of Iowa Studies in Child Welfare, Vol. II, No. 1, 56-58. Iowa City, Iowa: University of Iowa Press, 1922.

²⁴ Katherine Murdock and Louis R. Sullivan, "A Contribution to the Study of Mental and Physical Measurements in Normal Children," American Physical Education Review, XXVIII (1923), 209-15, 276-80, 328-30.

²⁵ Arthur I. Gates, "The Nature and Educational Significance of Physical Status and of Mental, Physiological, Social, and Emotional Maturity," Journal of Educational Psychology, XV (1924), 329-58.

²⁶ Ethel M. Abernethy, "Correlations in Physical and Mental Growth," Journal of Educational Psychology, XVI (1925), 458-66.

²⁷ Leta S. Hollingworth and Grace A. Taylor, "Size and Strength of Children Who Test above 135 I.Q.," Twenty-third Yearbook of the National Society for the Study of Education, 221-37. Bloomington, Illinois: Public School Publishing Co., 1924. Also by Hollingworth, Gifted Children, pp. 78-115. New York: The Macmillan Co., 1926.

²⁸ Lewis M. Terman and Others, Genetic Studies of Genius, Vol. I ("Mental and Physical Traits of a Thousand Gifted Children"), 135-71. Stanford University, California: Stanford University Press, 1925. (The part of the study cited was contributed by Bird T. Baldwin.)

ed from the studies of height and weight in relation to various criteria of intelligence. In the early investigations led by Baldwin²⁹ and by Woodrow,³⁰ a rough measure of total carpal area was correlated with mental age. Baldwin and Stecher had apparently negligible results, while Lowell and Woodrow found low positive coefficients. Prescott and Dearborn,³¹ Freeman and Carter,³² and Gates³³ adopted a more refined method of carpal measurement, and correlated the ossification ratio (the ratio of carpal area to the carpal quadrilateral) with mental age. The average of Prescott's coefficients for the various age groups is + .16; Gates' average for different sex and school groups is + .11; while Freeman and Carter, holding age constant by the technique of partial correlation, found still lower coefficients. The writer added data to those collected for girls in the Freeman and Carter study. The coefficients resulting from her statistical and experimental treatments of the problem are negligible.³⁴

Chest Girth and Lung Capacity in Relation to Intelligence

In several of the early studies of height and weight in relation to intelligence, it was reported that mentally inferior children are below the average in chest girth and in lung capacity, as well as in height and weight. Only one of the reports to which reference has been made in this chapter presents a definite statement of the amount of relationship--Gates' finding of an average coefficient of + .09 for each of these measures in relation to mental age.³⁵ Holzinger has reported a carefully conducted investigation of the relation of vital capacity to four primary psychical characters: reaction time to sound, reaction time to sight, keenness of vision, and highest audible pitch discernible. Data for 3,373 males were secured. The range in age was more than seventy years. When each of the variables was suitably corrected for age, there was found a positive correlation of .12 to .16 between vital capacity and the following three factors: reaction time to sight, reaction time to sound, and acuity of sight. There was no evidence of correlation between vital capacity and acuity of hearing.³⁶

Summary

Previous studies of mental and physical relationships in children have differed widely in the character of the populations studied, the criteria of intelligence selected, and the statistical procedures employed. It is significant that, with the diversity of techniques utilized, there is fairly consistent evidence of a slight positive correlation between certain physical traits and intelligence during the period of childhood. Height, standing or sitting, and weight have been found in nearly all the studies cited to be correlated to some degree with the measure of ability selected. (The three investigations in which teachers' judgments were used as the criterion of intelligence give the only exceptional results). This positive relationship has been noted when either feeble-minded or very

²⁹ Baldwin and Stecher, op. cit., p. 57.

³⁰ Frances Lowell and Herbert Woodrow, "Some Data on Anatomical Age and Its Relation to Intelligence," Pedagogical Seminary, XXIX (1922), 1-15.

³¹ Daniel Alfred Prescott, The Determination of Anatomical Age in School Children and Its Relation to Mental Development. Harvard Monographs in Education, Series I, No. 5. Cambridge, Massachusetts: Harvard University Press, 1923. Pp. iii + 60.

³² Frank N. Freeman and Thomas M. Carter, "A New Measure of the Development of the Carpal Bones and Its Relationship to Physical and Mental Development," Journal of Educational Psychology, XV (1924), 257-70.

³³ Op. cit., p. 342.

³⁴ Abernethy, op. cit., p. 462.

³⁵ Op. cit., p. 342.

³⁶ Karl J. Holzinger, "Note on the Relation of Vital Capacity to Certain Psychological Characters," Biometrika, XVI (1924), 139-56.

superior children have been compared in size with children unselected in ability; when total school populations have been classified according to some measure of intelligence; and, also, when highly selected ability groups have been studied separately. The other physical characters selected for the present investigation--namely, carpal development, chest girth, and lung capacity--appear to have less consistent correlation with intelligence than do height and weight. There is, however, evidence of a very low positive relationship between each of these physical traits and mental ability.

The studies reviewed in this chapter fail to give any acceptable explanation of the results secured. One is not justified in drawing from them any inferences concerning the nature of the relationship demonstrated. Only repeated measurements, continued until the approximate end of the period of development, can offer a key to the interpretation of the character of the association between mental and physical traits.

CHAPTER III

CORRELATION STUDIES OF THE BIRTHDAY MEASUREMENTS OF LABORATORY-SCHOOL CHILDREN

Problems

In the present study, analysis of the relation between mental and physical growth was first attempted through the correlation of the measures secured at the birthday examinations of the Laboratory-School children. This is the common cross-section type of investigation, made more precise by means of cumulative records of birthday tests and measurements. The repeated measuring of the subjects makes possible the consideration of an important problem of correlation not previously open to investigation--namely, the effect of approach to maturity upon the degree of relationship between the intelligence-test scores and the physical traits selected. This problem can be properly considered only when the same subjects have been measured repeatedly during the period of late adolescence. If the positiveness of the correlation found lessens with age, there is indicated a relationship in rate of mental and physical maturing, rather than a correlation in level of mental and physical status. Another new approach to analysis of the problem of mental and physical relationships has been opened through the data assembled. Since each child was measured on at least two consecutive birthdays, it has been possible to study the relation between increments in the mental and physical characters, determining the correlation of the variables in amount of gain from age to age. This phase of the study is significant in that it is suggestive of the degree of association between fluctuations in rate of mental and physical maturing. If so-called "spurts" of mental and physical growth are closely related, either positively or negatively, the relationship may be expected to appear in the coefficients of correlation between gains in mental and physical measures.

The Data

The correlation of birthday measurements.- The coefficients of correlation expressing the relations of scores on the psychological test to the physical variables are presented for each age group of each sex in Table I.

The coefficients are in nearly all cases positive and low.¹ In the data

¹ The correlation which exists seems, from inspection of the tables, to be linear. Tests of linearity made for tables with comparatively large populations tend

to support this impression. Blakeman's short test for linearity ($\sqrt{N} \sqrt{n^2 - r^2} < 4.047$) was employed. The data which follow are for psychological scores on the y-axis and standing height on the x-axis:

Age	Number of cases	Coefficient of correlation	Correlation ratio nyx	Test of linearity
12	116	.3296	.4060	2.555 < 4.047
13	115	.2890	.3910	2.821 < 4.047
14	112	.3288	.4467	3.199 < 4.047

The difference between the correlation ratio nyx and r is in each case small enough for the regression to be regarded as linear.

In case of the ratio nxr, however, the difference between the correlation ratio and r is slightly greater at ages thirteen and fourteen than the test for linearity allows. The data follow:

Age	Ratio nxr	Test of linearity
12	.4189	2.784 < 4.047
13	.4909	4.255 > 4.047
14	.5407	4.542 > 4.047

The data selected are typical of the correlation tables.

TABLE I

CORRELATION OF SCORES ON PSYCHOLOGICAL TEST
WITH MEASUREMENTS OF PHYSICAL TRAITS

Age	Boys	Girls	Physical Variables Correlated with Psychological Scores							
			Standing height				Sitting height			
			Boys		Girls		Boys		Girls	
			r	P.E. of r	r	P.E. of r	r	P.E. of r	r	P.E. of r
8	33	32	.16	±.11	.20	±.11	-.19	±.11	.05	±.12
9	58	65	.07	±.09	.07	±.08	-.02	±.09	-.03	±.08
10	91	92	.26	±.07	.21	±.07	.15	±.07	.09	±.07
11	112	114	.34	±.06	.13	±.06	.25	±.06	.07	±.06
12	116	112	.33	±.06	.15	±.06	.26	±.06	.16	±.06
13	115	95	.29	±.06	.12	±.07	.27	±.06	.16	±.07
14	112	89	.33	±.06	.21	±.07	.27	±.06	.20	±.07
15	94	77	.32	±.06	.18	±.07	.31	±.06	.23	±.07
16	62	51	.31	±.08	.17	±.09	.26	±.08	.09	±.09
17	32		.23	±.11			.25	±.11		
			Weight				Ossification ratio			
8			.10	±.12	-.04	±.12	.15	±.11	.02	±.12
9			.17	±.09	-.08	±.08	.05	±.09	.10	±.08
10			.25	±.07	.19	±.07	.02	±.07	-.06	±.07
11			.19	±.06	.18	±.06	.14	±.06	.05	±.06
12			.14	±.06	.16	±.06	.25	±.06	.07	±.06
13			.13	±.06	.20	±.07	.17	±.06	.17	±.07
14			.20	±.06	.18	±.07	.11	±.06	.06	±.07
15			.27	±.06	.16	±.07	.10	±.07	.13	±.08
16			.21	±.08	.05	±.10	.13	±.08	-.12	±.09
17			.12	±.12			.11	±.12		
			Chest girth				Lung capacity			
8			.04	±.12	-.17	±.12	.27	±.11		
9			.23	±.08	-.18	±.08	.12	±.09		
10			.14	±.07	.18	±.07	.23	±.07		
11			.15	±.06	.16	±.06	.19	±.06		
12			.11	±.06	.19	±.06	.24	±.06		
13			.05	±.06	.21	±.07	.14	±.06		
14			.07	±.06	.19	±.07	.16	±.06		
15			.16	±.07	.08	±.08	.12	±.07		
16			.01	±.09	-.02	±.10	-.04	±.09		
17			.14	±.12			.07	±.12		

* $r = -.02 \pm .12$ with the elimination of one extreme case.

for boys, only thirteen of the sixty coefficients are as much as four times their probable errors. Ten of these thirteen technically significant coefficients occur in the correlation of the mental-test scores with standing height and sitting height. The coefficients for girls are in no case significant by the statistical rule. The general consistency of the data seems, however, to overshadow this fact. There is rather convincing evidence of a slight positive relationship between the mental-test scores and each of the measures of physical growth. For each sex, standing height has the closest correlation with intelligence; sitting height and weight are next in correlation, with approximately equal significance. Measures of chest girth for boys, and of ossification ratio for both sexes are less

consistent than the measures of the other physical traits in regard to correlation with the mental-test scores.

In Table I, there may be noted a general trend of decreasing coefficients during the later part of the adolescent period. This loss in relationship between the mental and physical measurements is especially marked in the case of girls, who are much nearer than boys to physical maturity at the age of seventeen. A comparative study of coefficients of correlation at different periods of development is more highly significant when the same subjects are measured from age to age. Table II shows the change in correlation between the psychological scores and each of four physical traits in the case of forty-five girls who were measured for three consecutive birthdays. Without exception there is a decided decrease in correlation between ages fourteen and sixteen. The coefficients at age sixteen

TABLE II
CORRELATION BETWEEN PSYCHOLOGICAL SCORES AND VARIABLES OF
PHYSICAL GROWTH OF 45 GIRLS MEASURED FOR
THREE CONSECUTIVE BIRTHDAYS

Age at Birthday Examination	Coefficients of Correlation of Psychological Scores with			
	Standing height	Sitting height	Weight	Chest girth
14	.25 $\pm$.09	.21 $\pm$.10	.27 $\pm$.09	.15 $\pm$.10
15	.25 $\pm$.09	.23 $\pm$.10	.20 $\pm$.10	.09 $\pm$.10
16	.16 $\pm$.10	.06 $\pm$.10	.02 $\pm$.10	.02 $\pm$.10

are practically zero except in the case of standing height.

Psychological scores and measures of standing height were secured for forty-five girls on their sixteenth and seventeenth birthdays.² The correlation of mental-test scores with height at age sixteen is .16 $\pm$.10; at age seventeen, only .04 $\pm$.10.

Table III presents similar data for 44 boys for whom psychological scores and measures of three physical variables were secured at ages fifteen, sixteen, and seventeen. With approach to maturity, there is a decided loss in relationship between weight and the measure of intelligence. Standing height and sitting height, however, are almost as closely correlated with psychological scores at age seventeen as at fifteen.

TABLE III
CORRELATION BETWEEN PSYCHOLOGICAL SCORES AND VARIABLES OF
PHYSICAL GROWTH OF 44 BOYS MEASURED FOR
THREE CONSECUTIVE BIRTHDAYS

Age at Birthday Examination	Coefficients of Correlation of Psychological Scores with		
	Standing height	Sitting height	Weight
15	.28 $\pm$.09	.30 $\pm$.09	.25 $\pm$.09
16	.28 $\pm$.09	.31 $\pm$.09	.19 $\pm$.10
17	.26 $\pm$.09	.25 $\pm$.09	.01 $\pm$.10

² This group includes some of the subjects for whom data are given in Table II.

The results from the study of these constant groups of boys and girls agree rather closely with the data which appear in Table I for groups which are, to some extent, different in population from age to age. In most instances, there is a decline in correlation between mental and physical measurements during late adolescence. This trend is more marked in the case of girls, probably because of their earlier physical maturity. It is unfortunate that data are not now available for the following of much larger groups to complete maturity by this method.

Averages are in harmony with the evidence which has been presented of a somewhat marked correlation between the standing height and the psychological scores of boys in the present study. Each of three groups of boys was divided into two sections on the basis of rank in average height for a period of five consecutive birthday examinations. Differences both in the psychological scores and in the height of the taller and shorter divisions of each group are given in Table IV. There is a consistent difference in psychological scores in favor of the taller subjects. This difference is statistically significant at every age for the subjects whose period of measurement began at age ten; it is slightly lower for the later groups.

Intercorrelation of increments.— For each subject the amount of gain in each trait from birthday to birthday was determined. Intercorrelations of these increments appear in Table V (data for boys) and in Table VI (data for girls).

The increments in mental-test scores have no consistent relation to increments in any of the physical traits. Gains in the physical measures, on the other hand, are rather closely intercorrelated. With the understanding that there may be a spurious element involved in averaging coefficients for different age levels, the means of the r 's are given for each pair of variables in an attempt to present a summary of trends. There is apparently negligible correlation between the amount gained from year to year on the psychological test and the absolute gain in any of the physical traits. Gain in the ossification ratio is unrelated, during most periods, to gain in chest girth or lung capacity. Ossification ratio and weight show no consistent growth relationship.³ Other pairs of physical variables are, in general, fairly closely correlated. The most marked association in amount of gain is in standing height with sitting height, standing height with

³ The ossification ratio, rather than the total area of ossification, was the measure of carpal development selected for the correlation studies which are presented in this chapter (Tables I, V, and VI). However, the correlation coefficients between total ossified area and psychological scores at ages eleven and twelve were computed for the 97 boys and 90 girls who were measured at both these ages. The relationship between the gain in total ossification and the gain in other measurements between the eleventh and twelfth birthdays was also estimated.

The results follow:

Coefficients of correlation between scores

Age	Boys	Girls
11	.18 $\pm$.07	.10 $\pm$.07
12	.25 $\pm$.06	.04 $\pm$.07

Coefficients of correlation between increments

Total area of ossification with	Boys	Girls
Psychological scores	.04 $\pm$.07	.04 $\pm$.07
Standing height	.48 $\pm$.05	.41 $\pm$.06
Sitting height	.42 $\pm$.06	.23 $\pm$.06
Weight	.28 $\pm$.06	.15 $\pm$.06
Chest girth	.03 $\pm$.07	.13 $\pm$.07

The results agree with those for the ossification ratio, except that the coefficients of correlation between increments of total ossified area and increments of height and weight, are much higher at this age than the coefficients between increments of ossification ratio and the same measures (see Tables I, V, and VI).

DIFFERENCES IN MEAN PSYCHOLOGICAL SCORES FOR GROUPS OF BOYS
SELECTED ON THE BASIS OF STANDING HEIGHT

Group	Number in Group	Function Measured	Comparison of Averages	Age in Years				
				10	11	12	13	14
I	Total 35 (Taller group, 18; shorter group, 17)	Psycho- logical	Mean taller Mean shorter D	140.1 $\pm$ 3.7 116.9 $\pm$ 3.1 23.2 $\pm$ 4.8	163.3 $\pm$ 4.3 131.2 $\pm$ 4.5 32.1 $\pm$ 6.2	197.7 $\pm$ 4.9 155.6 $\pm$ 4.1 32.1 $\pm$ 6.4	206.5 $\pm$ 4.6 177.9 $\pm$ 4.4 28.6 $\pm$ 6.3	221.2 $\pm$ 5.1 194.7 $\pm$ 4.4 26.5 $\pm$ 6.7
		Standing height in inches	Mean taller Mean shorter D	56.1 52.7 3.4	58.2 54.7 3.5	60.5 56.5 4.0	63.1 59.1 4.0	66.3 62.1 4.2
II	Total 39 (Taller group, 20; shorter group, 19)	Psycho- logical	Mean taller Mean shorter D	164.4 $\pm$ 4.8 139.0 $\pm$ 4.9 25.4 $\pm$ 6.9	189.0 $\pm$ 4.5 162.1 $\pm$ 5.8 26.9 $\pm$ 7.3	204.8 $\pm$ 4.3 183.2 $\pm$ 5.3 21.6 $\pm$ 6.8	223.1 $\pm$ 4.4 201.5 $\pm$ 4.9 21.6 $\pm$ 6.6	235.8 $\pm$ 4.1 217.5 $\pm$ 4.5 18.3 $\pm$ 6.1
		Standing height in inches	Mean taller Mean shorter D	58.4 54.9 3.5	60.7 56.7 4.0	63.5 59.1 4.4	66.9 61.9 5.0	69.4 64.5 4.9
III	Total 40 (Taller group, 20; shorter group, 20)	Psycho- logical	Mean taller Mean shorter D	192.0 $\pm$ 5.0 178.7 $\pm$ 3.3 13.3 $\pm$ 6.0	212.3 $\pm$ 5.1 193.9 $\pm$ 5.0 18.4 $\pm$ 7.2	227.2 $\pm$ 4.3 209.6 $\pm$ 4.8 17.6 $\pm$ 6.4	245.8 $\pm$ 5.6 221.8 $\pm$ 3.8 24.0 $\pm$ 6.7	256.7 $\pm$ 5.1 238.8 $\pm$ 4.1 17.9 $\pm$ 6.5
		Standing height in inches	Mean taller Mean shorter D	63.5 58.9 4.6	66.8 61.7 5.1	69.2 64.4 4.8	70.3 66.7 3.6	70.8 67.9 2.9

TABLE V

INTERCORRELATION OF INCREMENTS FROM BIRTHDAY TO BIRTHDAY
IN ALL TRAITS MEASURED; DATA FOR BOYS

Age Interval	Number of Cases	Scores Psychological Test with:							Standing Height with:
		Standing height	Sitting height	Weight	Ossifica- tion ratio	Chest girth	Lung capacity	Sitting height	
8 - 9 . . .	33	-.14 $\pm$.12	-.03 $\pm$.12	-.32 $\pm$.11	.17 $\pm$.11	-.05 $\pm$.12	-.04 $\pm$.12	.49 $\pm$.09	
9 - 10 . . .	56	.40 $\pm$.08	-.11 $\pm$.09	.11 $\pm$.09	-.01 $\pm$.09	-.01 $\pm$.09	-.06 $\pm$.09	.17 $\pm$.09	
10 - 11 . . .	81	-.11 $\pm$.07	-.18 $\pm$.07	-.02 $\pm$.07	-.21 $\pm$.07	.01 $\pm$.07	-.03 $\pm$.07	.03 $\pm$.07	
11 - 12 . . .	97	-.17 $\pm$.07	-.25 $\pm$.06	-.21 $\pm$.07	.07 $\pm$.07	-.10 $\pm$.07	.05 $\pm$.07	.50 $\pm$.05	
12 - 13 . . .	95	-.09 $\pm$.07	-.03 $\pm$.07	.09 $\pm$.07	.06 $\pm$.07	-.06 $\pm$.07	.24 $\pm$.07	.72 $\pm$.03	
13 - 14 . . .	96	.13 $\pm$.07	.29 $\pm$.06	.09 $\pm$.07	.02 $\pm$.07	.09 $\pm$.07	.25 $\pm$.06	.72 $\pm$.03	
14 - 15 . . .	91	-.06 $\pm$.07	.08 $\pm$.07	-.04 $\pm$.07	.08 $\pm$.07	-.15 $\pm$.07	-.11 $\pm$.07	.61 $\pm$.04	
15 - 16 . . .	62	-.05 $\pm$.09	.01 $\pm$.09	-.07 $\pm$.09	.34 $\pm$.08	-.05 $\pm$.09	.00 $\pm$.09	.61 $\pm$.05	
Means of r's		.01	-.03	-.04	.06	.04	.04	.48	
Range of r's		.57	.54	.43	.55	.24	.36	.69	
		Standing Height with:				Sitting Height with:			
		Weight	Ossifica- tion ratio	Chest girth	Lung capacity	Weight	Ossifica- tion ratio	Chest girth	
8 - 9		.31 $\pm$.11	.26 $\pm$.11	.01 $\pm$.12	.20 $\pm$.11	.39 $\pm$.10	.22 $\pm$.11	.05 $\pm$.12	
9 - 10		.37 $\pm$.08	-.10 $\pm$.09	.14 $\pm$.09	.12 $\pm$.09	-.04 $\pm$.09	.28 $\pm$.08	-.17 $\pm$.09	
10 - 11		.23 $\pm$.07	.02 $\pm$.07	.25 $\pm$.07	.5 $\pm$.07	.20 $\pm$.07	.11 $\pm$.07	.11 $\pm$.07	
11 - 12		.62 $\pm$.05	.19 $\pm$.07	.12 $\pm$.07	.13 $\pm$.07	.33 $\pm$.06	.15 $\pm$.07	.02 $\pm$.07	
12 - 13		.51 $\pm$.05	.22 $\pm$.07	.35 $\pm$.06	.36 $\pm$.06	.39 $\pm$.06	.09 $\pm$.07	.26 $\pm$.06	
13 - 14		.61 $\pm$.04	.18 $\pm$.07	.47 $\pm$.05	.53 $\pm$.05	.52 $\pm$.05	.12 $\pm$.07	.39 $\pm$.06	
14 - 15		.45 $\pm$.06	.13 $\pm$.07	.40 $\pm$.06	.34 $\pm$.06	.43 $\pm$.06	.21 $\pm$.07	.27 $\pm$.07	
15 - 16		.56 $\pm$.06	.34 $\pm$.08	.38 $\pm$.07	.33 $\pm$.08	.44 $\pm$.07	.24 $\pm$.08	.25 $\pm$.08	
Means of r's		.44	.15	.20	.27	.33	.13	.15	
Range of r's		.39	.44	.44	.41	.56	.19	.56	
Age Interval	Sitting Height with:	Weight with:			Ossification Ratio with:		Chest girth with:		Lung capacity
		Lung capacity	Ossifica- tion ratio	Chest girth	Lung capacity	Chest girth	Lung capacity	Lung capacity	
8 - 9		.30 $\pm$.11	-.09 $\pm$.12	.58 $\pm$.08	.17 $\pm$.11	-.24 $\pm$.11	-.01 $\pm$.12	-.03 $\pm$.12	
9 - 10		.10 $\pm$.09	.00 $\pm$.09	.32 $\pm$.08	.17 $\pm$.09	-.12 $\pm$.09	.06 $\pm$.09	.11 $\pm$.09	
10 - 11		.17 $\pm$.07	.05 $\pm$.07	.59 $\pm$.05	.11 $\pm$.07	.02 $\pm$.07	-.02 $\pm$.07	-.03 $\pm$.07	
11 - 12		.04 $\pm$.07	-.01 $\pm$.07	.32 $\pm$.06	.13 $\pm$.07	-.10 $\pm$.07	.06 $\pm$.07	.01 $\pm$.07	
12 - 13		.09 $\pm$.07	.20 $\pm$.07	.50 $\pm$.05	.15 $\pm$.07	.02 $\pm$.07	.06 $\pm$.07	.05 $\pm$.07	
13 - 14		.41 $\pm$.06	.16 $\pm$.07	.46 $\pm$.05	.42 $\pm$.06	.01 $\pm$.07	-.08 $\pm$.07	.34 $\pm$.06	
14 - 15		.31 $\pm$.06	-.10 $\pm$.07	.52 $\pm$.05	.33 $\pm$.06	-.02 $\pm$.07	-.09 $\pm$.07	.44 $\pm$.06	
15 - 16		.35 $\pm$.08	.11 $\pm$.08	.54 $\pm$.06	.36 $\pm$.07	-.04 $\pm$.09	.10 $\pm$.08	.16 $\pm$.08	
Means of r's		.22	.04	.48	.23	-.06	.01	.13	
Range of r's		.37	.30	.27	.31	.26	.19	.47	

TABLE VI

INTERCORRELATION OF INCREMENTS FROM BIRTHDAY TO BIRTHDAY
IN ALL TRAITS MEASURED; DATA FOR GIRLS

Age Interval	Number of Cases	Scores Psychological Test with:						Standing Height with:	
		Standing height	Sitting height	Weight	Ossification ratio	Chest girth		Sitting height	Weight
8 - 9	38	.20 ± .11	.08 ± .12	-.13 ± .12	.05 ± .12	.00 ± .12		.48 ± .09	.30 ± .11
9 - 10	62	-.10 ± .08	.08 ± .08	.05 ± .09	.01 ± .09	.07 ± .09		.46 ± .07	.40 ± .07
10 - 11	80	-.10 ± .07	-.10 ± .07	-.19 ± .07	.06 ± .08	-.03 ± .08		.66 ± .04	.30 ± .07
11 - 12	90	-.06 ± .07	.01 ± .07	-.08 ± .07	-.08 ± .07	-.10 ± .07		.57 ± .06	.45 ± .06
12 - 13	79	-.05 ± .08	.08 ± .08	-.03 ± .08	-.09 ± .08	.02 ± .08		.68 ± .04	.33 ± .07
13 - 14	75	-.13 ± .08	-.01 ± .08	.10 ± .08	-.13 ± .08	-.01 ± .08		.65 ± .06	.33 ± .07
14 - 15	70	.06 ± .08	.05 ± .08	.01 ± .08	.02 ± .08	-.03 ± .08		.73 ± .04	.46 ± .06
15 - 16	51	.14 ± .09	.30 ± .09	.12 ± .09	-.05 ± .09	.06 ± .09		.45 ± .08	-.08 ± .09
Means of r's		.02	.06	-.02	-.02	.00		.58	.31
Range of r's		.33	.40	.31	.19	.17		.28	.52
		Standing Height with:		Sitting Height with:			Weight with:		Ossification ratio with:
		Ossification ratio	Chest girth	Weight	Ossification ratio	Chest girth	Ossification ratio	Chest girth	Chest girth
8 - 9		.56 ± .08	.23 ± .11	-.08 ± .12	.61 ± .07	.10 ± .12	.11 ± .12	.73 ± .06	.16 ± .12
9 - 10		-.02 ± .09	.29 ± .08	.37 ± .07	.13 ± .08	.24 ± .08	.14 ± .08	.47 ± .07	.05 ± .09
10 - 11		.25 ± .07	.15 ± .07	.21 ± .07	.30 ± .07	.14 ± .07	.20 ± .07	.48 ± .06	.21 ± .07
11 - 12		.14 ± .07	.19 ± .07	.27 ± .07	-.07 ± .07	.27 ± .07	.00 ± .07	.40 ± .06	.10 ± .07
12 - 13		.20 ± .07	.20 ± .07	.24 ± .07	.13 ± .07	.13 ± .07	.04 ± .08	.51 ± .06	.01 ± .08
13 - 14		.24 ± .07	.38 ± .07	.18 ± .08	.28 ± .07	.22 ± .07	.25 ± .07	.50 ± .06	.19 ± .08
14 - 15		.16 ± .08	.35 ± .07	.42 ± .07	.18 ± .08	.24 ± .08	.19 ± .08	.55 ± .06	.13 ± .08
15 - 16		-.06 ± .09	.14 ± .09	.30 ± .09	.04 ± .09	.21 ± .09	.32 ± .08	.32 ± .06	.09 ± .09
Means of r's		.19	.24	.24	.20	.19	.15	.49	.08
Range of r's		.62	.24	.50	.68	.17	.36	.41	.34

weight, and weight with chest girth. The low correlation of increments in standing height with increments in sitting height between the ninth and the eleventh birthdays in the case of boys (Table V), is in harmony with the percentage growth curves of Figure 2a, Chapter IV. Increase in the stature of the boys during this period is evidently due more largely to the growth of legs than to trunk growth.

Summary

The present study of mental- and physical-growth relationships deals first with the application of direct correlation technique to the data for Laboratory-School children. These data include intelligence-test scores and measures of standing height, sitting height, weight, carpal development, chest girth, and lung capacity. The results from the correlation of birthday measurements (mental-test scores with each of the indices of physical growth selected) are in fair accord with the data from similar studies. Each of the physical traits shows, in general, some positive correlation with the measure of intelligence. The coefficients are in most instances low; but for boys there is a rather marked relationship between standing height and the psychological scores. The general trend of decrease in coefficients after age fourteen or fifteen suggests that the relationship between the mental-test scores and each of the physical characters would be negligible at maturity. Study of the correspondence between rates of growth in the various traits selected is attempted through intercorrelation of absolute increments of growth. The results indicate no consistent relationship between the amount of gain on the psychological test and the amount of gain in any of the physical traits. Increments in the various physical characters are, on the other hand, rather closely interrelated.

The trend of decreasing correlations between mental and physical measures during late adolescence is in harmony with Whipple's hypothesis that the relationship is one of relative maturity.⁴ The second phase of the correlation study, the correlation of increments from birthday to birthday, apparently fails, however, to support this evidence. It may be that the unit of gain is too small to indicate correlation in rate of development, since, after all, the relationship between the mental and physical measures is low. In the chapter which follows, mental- and physical-growth curves are analyzed in the attempt to find another method of approach to the problem of correlation in rate of mental and physical development.

⁴ Guy Montrose Whipple, Manual of Mental and Physical Tests, Part I, p. 71. Baltimore: Warwick and York, 1914.

CHAPTER IV

COMPARISON OF MENTAL- AND PHYSICAL-GROWTH CURVES BASED UPON AVERAGES

Problems

In the preceding chapter, the problem of relationships between mental and physical growth was studied by means of direct correlation technique. The results of this method suggest that the positive correlation which exists between the mental and physical status of children during the period of development is not due to an association between fluctuations in rate of mental and physical growth. The inference that minor accelerations in mental and physical development are unrelated is based upon the results of the intercorrelation of yearly increments in the measures employed. Absolute gains in mental ability, as measured by the intelligence test, have no consistent relationship with absolute gains in any of the physical traits selected. Physical traits, on the other hand, are evidently in most cases closely interrelated in the matter of acceleration in growth.

The present chapter offers an additional approach to the problem of correlation between trends in rate of mental and physical maturing. Curves of mental and physical growth are presented because they reveal relationships undiscovered through direct correlation technique. The intercorrelation of increments from birthday to birthday involves a comparatively short unit of time, and fails to give a conception of the form of the growth curve for the various traits measured. The growth curves which appear in the present chapter show variations in rate of both mental and physical development throughout the period studied, from age eight through seventeen. These curves make possible the comparison of one type of physical growth with another, and also show contrasts between the form of the mental-growth curve and the general trend of physical development.

Another problem considered in the analysis of growth curves is that of sex differences in mental growth. Girls differ from boys in rate of physical maturing. This fact suggests the following question: Do corresponding differences appear in curves of mental growth for the two sexes?

The Data

The growth curves which appear in the present chapter are of several types. First, curves in absolute units of measurement are presented in Table VII and Figure 1. The means are based upon all of the data secured from the mental and physical measurements of the subjects throughout the period of investigation.¹ There is overlapping of populations from age to age since each child was measured on at least two consecutive birthdays. Growth curves in absolute units are not easily comparable, hence the study of rate of development is continued through the analysis of relative growth curves. These percentage curves, shown in Figure 2, represent graphically the data of Tables VIII and IX. Percentage growth curves for groups of the same children measured for five consecutive birthdays, follow in Figures 3 and 4.² In conclusion, a method of analyzing rate of growth is considered, and curves which emphasize fluctuations in growth rate are presented (Table X and Figure 5).

¹ The data of Table VII do not include certain supplementary measurements of girls and boys at ages sixteen and seventeen. These later measures were added in order to increase the number of cases in the five-year runs (Figures 3 and 4).

² Data upon which these curves are based are given in Tables IV and V of the Appendix.

TABLE VII

MEANS, STANDARD DEVIATIONS, AND COEFFICIENTS OF VARIATION
FOR MEASUREMENTS OF EACH TRAIT AT EACH AGE

		Scores Psychological Test															
Age		Number of Cases	Boys			Girls											
			Mean	Standard deviation	Coefficient of variation	Mean	Standard deviation	Coefficient of variation									
		Boys							Girls								
8		33	32	86.1	3.3	28.3	2.3	32.1	2.9	86.4	2.3	19.4	1.6	22.5	2.0		
9		58	65	108.1	2.3	26.2	1.6	24.2	1.6	104.8	2.1	25.4	1.5	24.2	1.5		
10		91	92	131.1	2.2	31.2	1.6	33.8	1.3	126.4	1.9	26.9	1.3	21.0	1.1		
11		112	114	150.0	2.0	32.1	1.4	21.4	1.0	151.4	1.9	29.4	1.3	19.4	0.9		
12		116	112	170.4	2.1	33.5	1.5	19.7	0.9	169.9	1.9	30.5	1.3	18.0	0.8		
13		115	96	190.9	2.2	35.1	1.6	15.4	0.8	191.7	2.2	31.8	1.6	16.6	0.8		
14		112	89	205.8	2.2	34.9	1.6	17.0	0.8	208.2	2.1	29.7	1.5	14.3	0.7		
15		94	77	220.0	2.4	34.5	1.7	15.7	0.8	218.7	2.0	25.9	1.4	11.8	0.7		
16		62	51	232.1	2.9	34.0	2.1	14.6	0.9	226.7	2.3	23.9	1.6	10.5	0.7		
17		32	27	235.4	3.8	31.9	2.7	13.6	1.2	226.9	2.7	20.4	1.9	8.9	0.8		
Total Area of Ossification																	
Ossification Ratio																	
Age		Boys			Girls			Boys									
		Mean	Standard deviation	Coefficient of variation	Mean	Standard deviation	Coefficient of variation	Mean	Standard deviation	Coefficient of variation							
8		109.0	2.8	24.13	1.98	22.1	1.9	126.1	3.0	25.39	2.12	20.1	1.8	.615	.011	.097	± .008
9		137.9	2.1	24.12	1.48	17.5	1.1	149.2	2.2	26.07	1.56	17.5	1.1	.608	.007	.082	± .005
10		166.5	2.2	31.53	1.56	18.9	1.0	182.1	2.2	31.05	1.56	17.1	0.9	.689	.007	.091	± .004
11		195.6	2.5	39.24	1.77	20.1	0.9	214.4	2.2	34.70	1.56	16.2	0.7	.769	.007	.103	± .005
12		231.9	2.7	43.47	1.91	18.7	0.9	242.9	2.3	35.58	1.63	14.6	0.7	.865	.007	.089	± .006
13		276.5	2.9	45.54	2.05	16.5	0.8	265.6	2.3	33.85	1.63	12.7	0.6	.956	.006	.088	± .004
14		314.4	3.1	48.07	2.19	15.3	0.7	278.8	2.6	35.86	1.84	12.9	0.6	1.024	.004	.070	± .003
15		349.6	3.0	43.58	2.12	12.6	0.6	288.0	2.6	34.22	1.84	11.9	0.7	1.072	.004	.061	± .003
16		379.6	3.5	41.40	2.47	10.9	0.7	299.9	3.4	36.07	2.40	12.0	0.8	1.115	.005	.053	± .004
17		401.7	5.1	43.17	3.61	10.7	0.9	300.4	4.8	37.04	3.39	12.3	1.1	1.154	.008	.064	± .006
Ossification Ratio																	
Standing Height in Inches																	
Age		Boys			Girls			Boys			Girls						
		Coefficient of variation	Mean	Standard deviation	Coefficient of variation	Mean	Standard deviation	Coefficient of variation	Mean	Standard deviation	Coefficient of variation	Mean					
8		18.8	1.6	.674	± .012	104	.008	15.4	1.3	51.3	± .2	1.76	± .14	3.43	± .29	50.9	± .2
9		13.5	0.9	.785	± .008	102	.006	12.0	0.7	53.6	± .2	2.07	± .14	3.86	± .24	53.0	± .2
10		13.2	0.7	.867	± .007	109	.005	11.6	0.6	55.3	± .2	2.38	± .14	4.30	± .22	55.1	± .2
11		13.4	0.6	.946	± .006	108	.004	9.4	0.4	57.4	± .2	2.36	± .14	4.11	± .19	57.4	± .2
12		12.5	0.6	1.019	± .005	108	.004	7.3	0.4	59.3	± .2	2.61	± .14	4.40	± .20	59.5	± .2
13		9.3	0.4	1.061	± .004	104	.004	6.0	0.3	61.7	± .2	2.92	± .14	4.73	± .21	61.7	± .2
14		6.8	0.3	1.097	± .004	106	.005	5.1	0.3	64.2	± .2	3.25	± .14	5.06	± .23	63.3	± .2
15		5.7	0.3	1.123	± .004	104	.003	4.7	0.3	66.6	± .2	3.05	± .14	4.58	± .23	64.0	± .2
16		4.8	0.3	1.136	± .005	103	.004	4.7	0.3	68.6	± .2	2.60	± .14	3.79	± .23	64.7	± .2
17		5.5	0.5	1.164	± .008	103	.006	5.4	0.5	68.8	± .3	2.69	± .21	3.91	± .33	64.5	± .3
Sitting Height in Inches																	
Age		Boys			Girls			Boys			Girls						
		Standard deviation	Coefficient of variation	Mean	Standard deviation	Coefficient of variation	Mean	Standard deviation	Coefficient of variation	Mean	Standard deviation	Coefficient of variation					
8		1.65	± .14	3.24	± .27	27.6	± .1	0.76	± .07	2.75	± .23	27.2	± .1	0.97	± .07	3.57	± .30
9		2.19	± .14	4.13	± .24	28.4	± .1	0.97	± .07	3.42	± .21	28.1	± .1	1.09	± .07	3.88	± .23
10		2.49	± .14	4.82	± .23	29.1	± .1	1.13	± .07	4.06	± .20	29.0	± .1	1.31	± .07	4.52	± .23
11		2.81	± .14	4.90	± .22	29.8	± .1	1.18	± .07	3.99	± .18	30.0	± .1	1.44	± .07	4.86	± .23
12		2.83	± .14	4.76	± .22	30.5	± .1	1.24	± .07	4.07	± .18	31.0	± .1	1.57	± .07	5.02	± .23
13		2.56	± .14	4.15	± .20	31.6	± .1	1.48	± .07	4.68	± .21	32.1	± .1	1.48	± .07	4.61	± .23
14		2.45	± .14	3.87	± .20	32.8	± .1	1.78	± .07	5.43	± .25	33.0	± .1	1.42	± .07	4.30	± .22
15		2.12	± .14	5.33	± .18	34.1	± .1	1.86	± .07	5.45	± .27	33.5	± .1	1.26	± .07	3.76	± .20
16		2.15	± .14	5.32	± .22	35.4	± .1	1.67	± .07	4.78	± .29	34.1	± .1	1.25	± .07	3.67	± .25
17		1.96	± .21	5.02	± .28	35.9	± .2	1.64	± .14	4.57	± .39	34.1	± .1	1.15	± .07	3.37	± .31
Weight in Pounds																	
Age		Boys			Girls			Boys			Girls						
		Mean	Standard deviation	Coefficient of variation	Mean	Standard deviation	Coefficient of variation	Mean	Standard deviation	Coefficient of variation	Mean	Standard deviation	Coefficient of variation				
8		60.5	± 0.8	7.1	± 0.6	11.7	± 1.0	62.0	± 0.9	7.3	± 0.6	11.8	± 1.0	24.2	± 1.1	1.25	± .07
9		69.2	± 0.9	10.2	± 0.6	14.7	± 0.9	69.1	± 0.9	10.3	± 0.6	14.9	± 0.9	25.2	± 1.1	1.61	± .07
10		74.2	± 0.8	11.1	± 0.6	15.0	± 0.8	76.1	± 0.9	12.3	± 0.6	15.9	± 0.8	26.1	± 1.1	1.63	± .07
11		81.5	± 0.8	12.6	± 0.6	15.5	± 0.7	84.6	± 0.9	14.4	± 0.6	17.0	± 0.8	26.7	± 1.1	1.80	± .07
12		88.8	± 0.9	14.3	± 0.6	16.1	± 0.7	94.0	± 1.0	15.6	± 0.7	16.5	± 0.8	27.5	± 1.1	1.87	± .07
13		99.1	± 1.0	16.2	± 0.7	16.3	± 0.7	104.6	± 1.2	16.8	± 0.8	16.1	± 0.8	28.4	± 1.1	2.11	± .07
14		109.9	± 1.1	17.0	± 0.8	15.5	± 0.7	113.5	± 1.2	17.3	± 0.8	15.8	± 0.8	29.8	± 1.1	2.12	± .07
15		122.2	± 1.3	18.0	± 0.9	14.7	± 0.7	121.5	± 1.2	18.0	± 0.8	12.8	± 0.7	31.0	± 1.1	2.11	± .07
16		133.2	± 1.5	17.4	± 1.1	13.1	± 0.8	123.3	± 1.4	14.6	± 1.0	11.8	± 0.8	32.3	± 1.2	2.04	± .14
17		141.2	± 2.0	17.2	± 1.4	12.2	± 1.0	121.2	± 1.9	14.7	± 1.3	12.1	± 1.1	33.0	± 1.2	1.82	± .14
Normal Chest Girth in Inches																	
Age		Boys			Girls			Boys			Girls						
		Coefficient of variation	Mean	Standard deviation	Coefficient of variation	Mean	Standard deviation	Coefficient of variation	Mean	Standard deviation	Coefficient of variation	Mean	Standard deviation	Coefficient of variation			
8		5.17	± .43	24.9	± .1	1.08	± .07	4.34	± .37	102.0	± 1.8	15.4	± 1.3	15.1	± 1.3		
9		6.39	± .40	25.3	± .1	1.62	± .07	6.40	± .38	103.8	± 1.4	15.5	± 1.0	14.9	± 1.0		
10		6.25	± .31	26.6	± .1	1.74	± .07	6.54	± .33	127.3	± 1.4	19.7	± 1.0	15.5	± 0.8		
11		6.74	± .31	27.5	± .1	1.97	± .07	7.16	± .32	134.5	± 1.3	20.0	± 0.9	14.9	± 0.7		
12		6.80	± .30	28.6	± .1	2.15	± .07	7.52	± .34	145.7	± 1.3	21.4	± 0.9	14.7	± 0.7		
13		7.43	± .33	30.0	± .1	2.09	± .07	6.97	± .34	165.0	± 1.7	26.7	± 1.2	16.2	± 0.7		
14		7.11	± .32	31.0	± .1	2.04	± .07	6.58	± .33	188.8	± 2.2	35.1	± 1.6	18.6	± 0.9		
15		6.81	± .34	31.0	± .1	1.93	± .07	6.23	± .34	211.8	± 2.5	35.4	± 1.8	16.7	± 0.8		
16		6.32	± .38	31.5	± .2	1.70	± .07	6.40	± .36	237.9	± 3.6	41.4	± 2.5	17.4	± 1.1		
17		5.52	± .47	31.0	± .3	1.93	± .21	6.23	± .57	282.9	± 4.3	35.7	± 3.0	14.1	± 1.2		

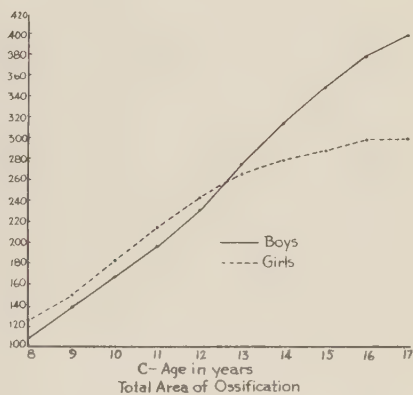
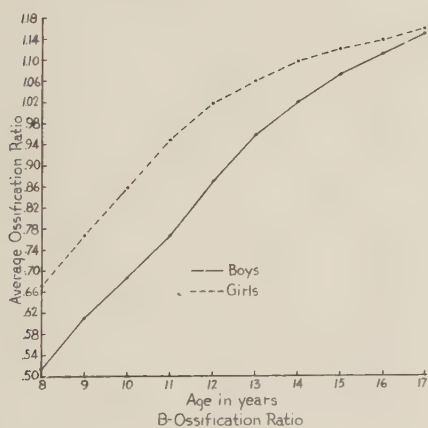
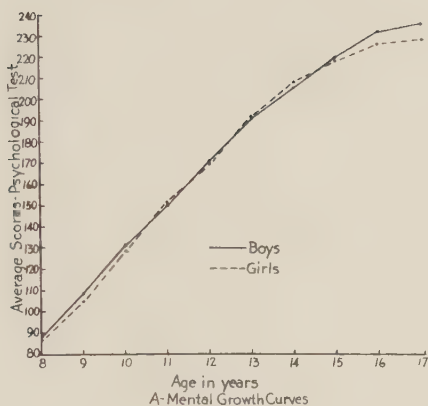


Figure 1.- Mental- and physical-growth curves of boys and girls; data, the means in Table VI.

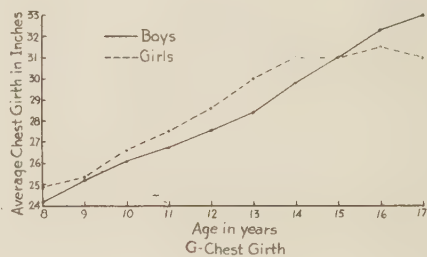
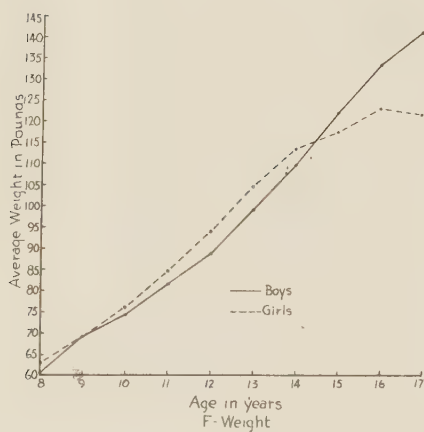
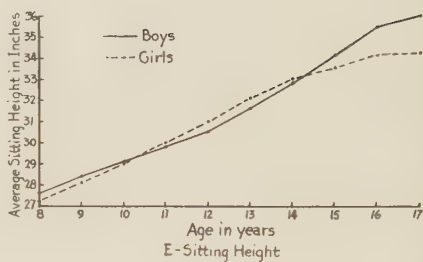
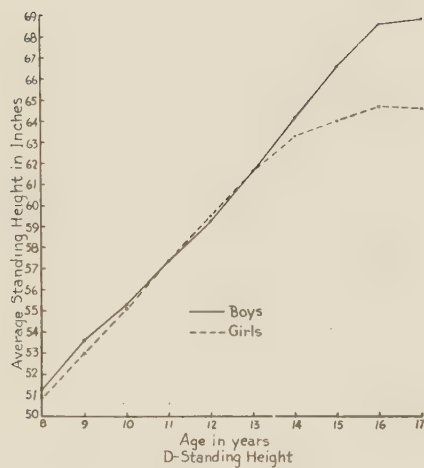


Figure 1.- Continued

TABLE VIII

RATIO OF INCREMENT DURING EACH BIRTHDAY INTERVAL TO INCREMENT
DURING THE TOTAL PERIOD OF NINE YEARS; DATA FOR ALL CASES

Function	Sex	Percentage of Total Increment during Interval:									
		8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	
Psychological	Boys	13.58	15.61	12.93	13.85	13.92	10.12	9.64	8.21	2.24	
	Girls	12.91	16.58	16.14	13.98	15.30	11.58	7.37	5.61	1.54	
Ossification Ratio	Boys	14.55	12.68	12.52	15.02	14.24	10.84	7.51	6.42	6.42	
	Girls	18.57	18.78	18.16	14.90	8.57	7.35	5.31	2.65	5.71	
Total Ossification	Boys	9.87	9.77	9.84	12.40	14.90	17.29	12.08	10.18	7.85	
	Girls	13.25	18.88	18.53	16.35	13.02	7.57	5.28	6.53	0.29	
Standing Height	Boys	13.14	9.71	12.00	10.86	13.71	14.29	13.71	11.43	1.14	
	Girls	15.22	15.22	13.87	15.22	15.94	11.59	8.07	5.07	-1.45	
Sitting Height	Boys	9.64	8.45	8.43	8.43	13.25	14.46	14.67	15.67	6.02	
	Girls	13.04	13.04	14.49	14.49	15.94	13.74	7.25	8.70	0	
Weight	Boys	10.79	6.20	9.05	9.05	12.76	13.38	15.24	13.63	9.91	
	Girls	11.58	11.42	13.67	15.33	17.29	14.52	6.53	9.46	-3.43	
Chest Girth	Boys	11.36	10.23	6.82	9.99	11.23	15.01	13.04	14.77	7.35	
	Girls	6.06	13.70	13.64	16.67	21.21	15.15	0	7.58	-7.58	
Lung Capacity	Boys	1.19	15.57	4.77	7.42	12.79	17.77	15.14	17.50	4.94	

TABLE IX

PERCENTAGE GROWTH CURVES FOR THE TOTAL PERIOD OF MEASUREMENT;
BASED UPON THE DATA IN TABLE VIII

Trait	Sex	Percentage of Total Increment for the Period at Age:									
		8	9	10	11	12	13	14	15	16	17
Psychological	Boys	0 13.58	29.19	42.02	55.87	69.79	79.91	89.55	97.76	100.00	
	Girls	0 12.91	29.47	45.61	58.59	73.89	85.47	92.84	98.45	99.99	
Ossification Ratio	Boys	0 14.55	27.23	39.75	54.77	69.01	79.65	87.16	93.58	100.00	
	Girls	0 16.57	37.35	55.51	70.41	78.98	86.33	91.64	94.29	100.00	
Total Ossification	Boys	0 9.87	19.64	29.58	41.98	56.88	70.17	82.26	92.44	99.99	
	Girls	0 13.25	32.13	50.66	67.01	80.03	87.60	92.38	98.71	100.00	
Standing Height	Boys	0 13.14	22.85	34.85	45.71	59.42	73.71	87.42	98.35	99.99	
	Girls	0 15.22	30.44	47.11	62.33	78.27	89.86	94.93	100.00	98.55	
Sitting Height	Boys	0 9.64	18.07	26.50	34.93	48.18	62.64	78.31	93.98	100.00	
	Girls	0 13.04	26.08	40.57	55.06	71.07	84.04	91.29	99.99	99.99	
Weight	Boys	0 10.79	16.99	26.04	35.09	47.85	61.23	76.47	90.10	100.00	
	Girls	0 11.58	23.00	36.07	52.20	69.49	84.91	90.54	100.00	96.87	
Chest Girth	Boys	0 11.36	21.59	28.41	37.50	47.73	63.64	77.28	92.05	100.00	
	Girls	0 6.06	25.76	39.40	52.00	62.00	77.20	84.43	92.43	100.00	
Lung Capacity	Boys	0 1.19	16.76	21.53	28.95	41.74	57.51	72.75	90.05	100.00	

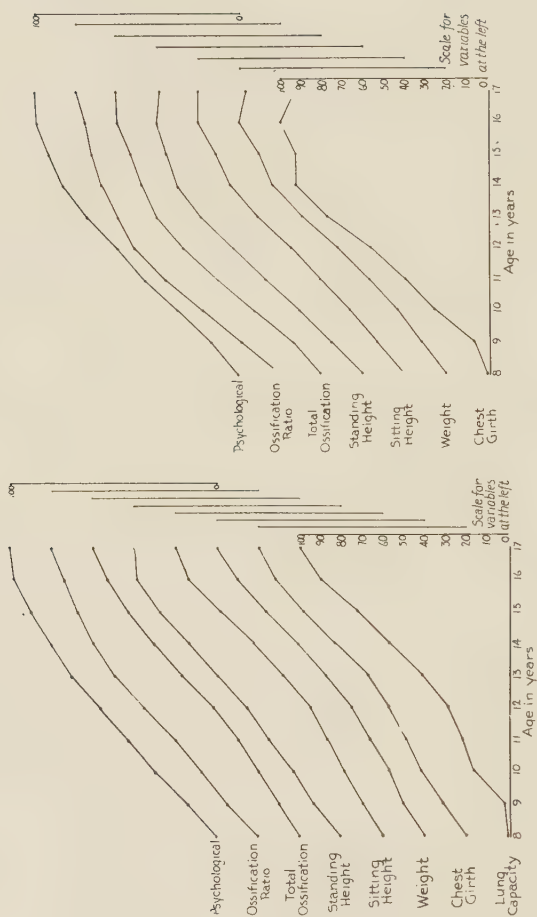


Figure 2a.- Data for boys

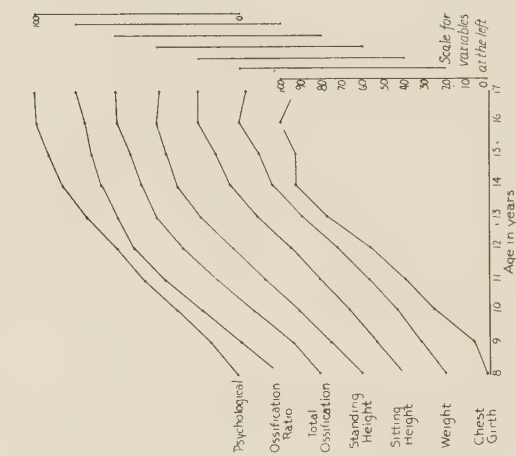


Figure 2b.- Data for girls

Figure 2.- Percentage growth curves for boys and girls; data for all subjects.

(Explanation of the method of deriving these curves is given on page 25.)

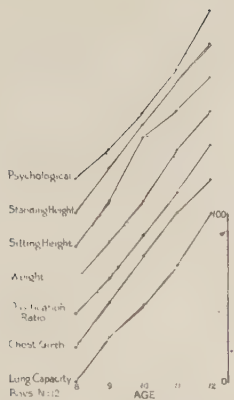


Figure 3a.- Data for 12 boys

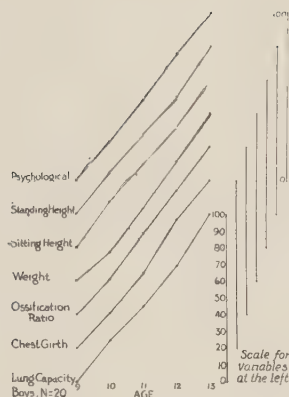


Figure 3b.- Data for 20 boys

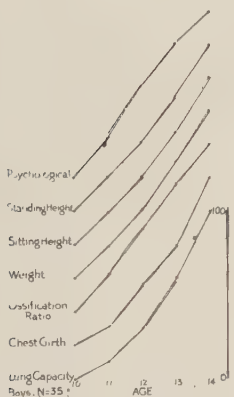


Figure 3c.- Data for 35 boys

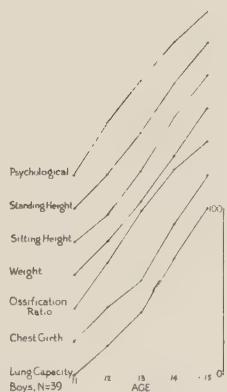


Figure 3d.- Data for 39 boys

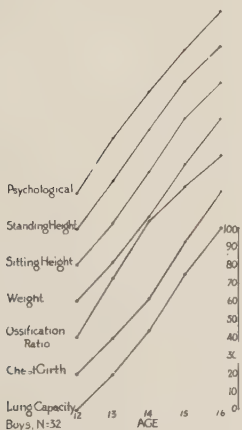


Figure 3e.- Data for 32 boys

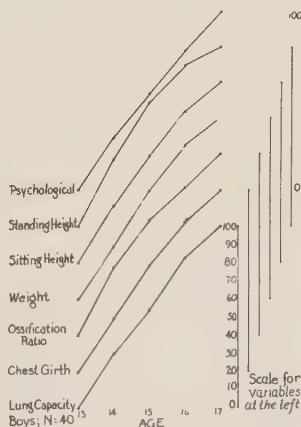


Figure 3f.- Data for 40 boys

Figure 3.- Percentage growth curves for six groups of boys, each group measured for five consecutive birthdays.

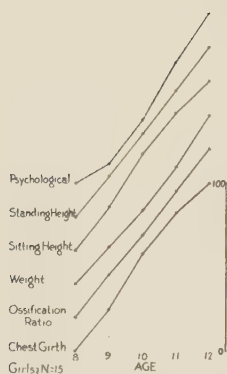


Figure 4a.- Data for 15 girls

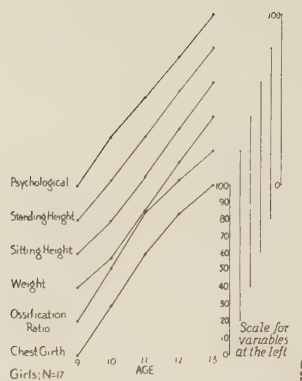


Figure 4b.- Data for 17 girls

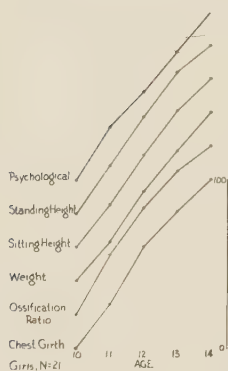


Figure 4c.- Data for 21 girls

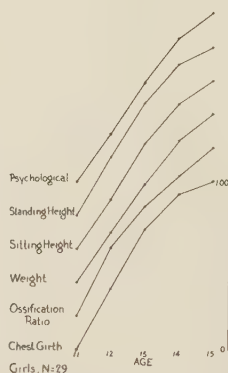


Figure 4d.- Data for 29 girls

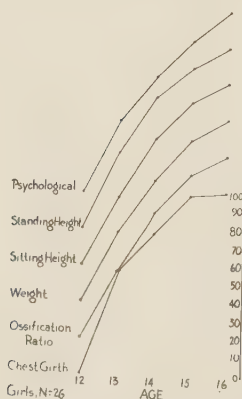


Figure 4e.- Data for 26 girls

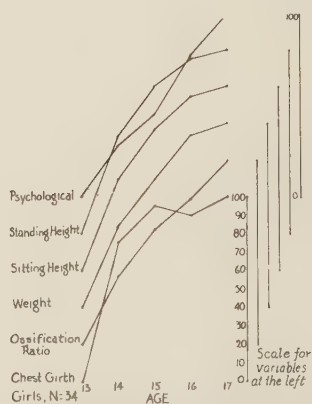


Figure 4f.- Data for 34 girls

Figure 4.- Percentage growth curves for six groups of girls, each group measured for five consecutive birthdays.

The percentage growth curves of Figures 2-4 require explanation. All curves within a figure are of the same dimension vertically and represent interrelationships in rate of development within the period of measurement. The data in Tables VIII and IX, upon which Figure 2 is based, illustrate the principle of these curves. For example, Table VIII shows that the gain for boys on the psychological test between the eighth and ninth birthdays is 13.58 per cent of the total gain from eight to seventeen; while between the ninth and tenth birthdays, 15.61 per cent of the nine-year increment takes place. Table IX gives the cumulative percentages. Measurement begins with the eighth birthday; by the ninth, 13.58 per cent of the nine-year increment has taken place; by the tenth, 29.19 per cent; etc. Each curve ends, of course, with 100 per cent (or its approximate) unless there has been loss following the attainment of the maximum. Loss occurs at age seventeen in three instances for girls when the populations are not the same from age to age (Tables VII-IX, and Figures 1-2).

Analysis of the growth curves.- Analysis of Figures 1 and 2 shows that the curve of mental growth for both sexes is approximately a straight line until the thirteenth birthday. Following this age, there is a gradual decline in rate of growth. The marked loss in increment between the sixteenth and seventeenth birthdays is probably due to selection. The average age of students at the time of graduation from the University High School is seventeen. Students accelerated in school progress may complete the course before the seventeenth birthday. Such students would tend to have a high rank in the psychological scores. Inspection of the primary data shows that some subjects with very high scores do leave school at the age of sixteen. Other evidence that selection is the probable factor in the marked drop after sixteen in the curve of psychological scores for all subjects, is to be found in data for groups constant in population from the thirteenth birthday to the seventeenth (Figure 3f for boys and 4f for girls). For neither of these groups is there pronounced negative flexion in the curve of mental growth following the sixteenth birthday.³ The mental-growth curves for constant groups (Figures 3-4) show in nearly every instance some retardation in rate after the thirteenth birthday; but the trend is not entirely consistent. It may be that the negative acceleration after age thirteen in the mental-growth curves for the entire body of boys and girls tested (Figures 2a and 2b) is due to some extent to selective factors which have not been detected. In general, the curves for the various constant groups shown in Figures 3 and 4 are essentially in conformity with the curves for all subjects presented in Figures 1 and 2.⁴

The slight sex differences which appear in the curves of mental growth for all cases are apparently due likewise to sampling errors. In the mental-growth curves of Figure 1, boys and girls are compared in average psychological scores at every age from the eighth birthday to the seventeenth. The means for the two sexes are approximately the same throughout the

³ Mental-growth curves for secondary-school pupils have been obtained through the group retest method, with an interval of one year, by Thorndike and by Johnson. (Edward L. Thorndike, "On the Improvement in Intelligence Scores from Fourteen to Eighteen," *Journal of Educational Psychology*, XIV (1923), 513-16; *Ibid.*, "On the Improvement of Intelligence Scores from Thirteen to Nineteen," *Journal of Educational Psychology*, XVII (1926), 73-76; William H. Johnson, "The Mental Growth Curve of Secondary School Students." Unpublished Doctor's thesis, Dept. of Education, University of Chicago, 1923. Pp. 141). Each of these investigators has reported a fairly straight-line development to the end of the high-school period. The subjects employed by Johnson ranged in age from twelve to eighteen. The ages of Thorndike's subjects are indicated in the titles of his articles.

Data concerning the mental-growth curve beyond the high-school period are available for certain subjects in the present study. Professor Frank N. Freeman has continued the examinations of subjects who have remained in the University after high-school graduation, with the finding of considerable improvement in the mental-test scores through college years. (Reference is to the Unpublished report of Freeman cited in Chapter I).

⁴ The curves have not been smoothed at any point.

period except at sixteen and seventeen, at which ages the girls drop below the scores for boys. Again, reference to data for groups of the same children suggests that selection is the basis of the observed differences. Tables II and III of the Appendix contain the absolute measures which are presented in relative units in Figures 3f and 4f. The average psychological scores for 40 boys and 34 girls measured on each birthday from the thirteenth to the seventeenth, follow:

Age	13	14	15	16	17
Boys	185.4	203.1	218.4	233.8	247.7
Girls	185.9	203.2	213.6	234.3	248.5

The means for the two sexes are strikingly similar at every age except fifteen. There is no evidence here of sex difference in mental development.⁵ Data for these constant groups are more significant than those for groups which differ to some extent in population from age to age.

While this study offers no consistent evidence of sex differences in rate of mental growth, boys and girls are found to differ rather markedly in characteristics of physical development. Figure 2 shows that the physical-growth curves of boys are positively accelerated during the period of early adolescence. Acceleration in the physical curves of girls is decidedly less pronounced during this period of development.⁶ There is very little loss in the rate of development of any of the physical traits of boys before the sixteenth birthday. Negative flexion in the growth curves of girls, on the other hand, appears between the thirteenth and fourteenth birthdays in all of the physical measures except that of ossification, which shows a slight decline about two years earlier.

The physical-growth curves which appear in Figures 1 and 2 are essentially in harmony with curves of the same physical traits reported by investigators who have measured much larger numbers of boys and girls. Examination of the tables of averages presented in literature reveals agreement concerning the earlier physical maturity of girls. Girls grow more rapidly than boys until about the age of fourteen, and then more slowly. Acceleration in growth rate begins about two or three years later for boys than for girls, and extends over a longer period.⁷ Girls are ahead of

⁵ Professor Freeman has found, in his continuation of the mental-growth study, that the mental-growth curves of young women in college are similar to those of college men. The students of college age employed were subjects of the present study who were available for the continuing of examinations after graduation from high school (footnote 3).

Terman has reported different results from his retests of gifted boys and girls. (Barbara Stoddard Burks, Dortha Williams Jensen, Lewis M. Terman, and Others, Genetic Studies of Genius, Vol. III ("The Promise of Youth: Follow-up Studies of a Thousand Gifted Children"), 23-62. Stanford University, California: Stanford University Press, 1930.) Terman's conclusion follows: "Boys not only become increasingly more likely than girls to have a high I.Q. as they advance in age, but they are more likely than girls to retain a high I.Q. earlier evidenced."

⁶ Data presented in Chapter VI for individuals and for groups, show that there is a slight acceleration in the rate of growth of girls in certain physical traits during the year preceding the year of onset of puberty. This acceleration is apparent for groups which are selected with regard to age of physiological maturation; it is clearly evident in the physical-growth curves of most of the individuals for whom measurements were obtained. Averages for chronological age groups tend to obscure this slight positive acceleration in the curves of height and weight of girls prior to the advent of puberty.

⁷ Baldwin's summary of data from a large number of investigations of height and weight is given in comparative tables in connection with his own data. (Bird T. Baldwin, The Physical Growth of Children from Birth to Maturity, University of Iowa Studies in Child Welfare, Vol. I, No. 1, 237-319. Iowa City: The University of Iowa, 1921). A recent publication by Gray and Ayres gives references to many physical-growth studies which have been reported since Baldwin's monograph, and also reports an intensive study of body growth in 4,583 private-school children. (Horace Gray and J. G. Ayres, Growth in Private School Children. Chicago: The University of Chicago Press, 1931. Pp. xv + 282.)

boys at all ages prior to seventeen in ossification ratio, and exceed boys in total area of ossification until twelve or thirteen.⁸ Studies of development in lung capacity show marked positive acceleration in this function for boys during the period of adolescence.⁹

Data for the six groups of boys constant in population for five consecutive birthdays (Figure 3) have been analyzed with respect to rate of growth. Rate of growth in each trait has been estimated by using as a base for ratios the gain during the first year of the four-year period of measurement, dividing this increment of the initial year into the increment of each following year. The results are presented in Table X for the six groups, and in Figure 5 for four of these groups.

Variations in the rate of physical growth of these subjects apparently do not affect the rate of growth in intelligence, as measured by the test employed. For example, reference may be made to the data for Group IV, Table X (Figure 5b). The fairly general positive acceleration in physical growth during the period from eleven to fifteen is not accompanied by increase in rate of mental development for these subjects. On the contrary, the mental-growth curve is somewhat negatively accelerated.

Inspection of data for all the groups suggests that one can not predict from the general trend of growth rate in the physical characters selected, the rate of development in test intelligence of this type.

Summary

Data presented in this chapter show significant differences between the mental- and physical-growth curves of the subjects selected. The mental-growth curve, as determined by the units of measurement employed, continues with but slight negative acceleration after physical maturity has been almost completely reached. Moreover, analysis of the growth curves throughout the period of measurement, ages eight through seventeen, reveals no relationship between fluctuations in rate of mental and physical development. Positive acceleration in rate of physical development is not accompanied by a corresponding change in rate of mental growth, nor do the points of decline in rate of mental and physical maturing appear to be related consistently. The mental-growth curve for both boys and girls is slightly negative in flexion after the thirteenth birthday, at which period the growth rate of boys is positively accelerated in every physical trait selected for the present study. Girls, on the other hand, have decline in curves of certain physical traits even before the thirteenth birthday.

The results from this study indicate that, notwithstanding pronounced sex differences in rate of physical maturing, the boys and girls used as subjects have a very similar type of mental development. Similarity between the curves of intelligence for the two sexes is especially striking when repeated measurements are made of groups of boys and girls constant in population over a period of years. There is no consistent evidence that the earlier physical maturing of the girls is associated with more rapid mental development and earlier cessation of mental growth.

Results of the study thus far are mainly negative with respect to correlation in rate of mental and physical growth. The data of this chapter agree with those presented in the preceding one in that there is no suggestion, either through correlation technique or the plotting of curves

⁸ Paul M. Cook, "The Significance of Anatomical Development in Relation to Certain Educational Problems." Unpublished Master's thesis, Dept. of Education, University of Chicago, 1927. Pp. 92.

⁹ Karl J. Holzinger, "Note on the Relation of Vital Capacity to Certain Psychological Characters," *Biometrika*, XVI (1924), 141.

TABLE X

RATE OF GROWTH IN VARIOUS TRAITS FOR SIX GROUPS OF BOYS, EACH GROUP MEASURED FOR FIVE CONSECUTIVE BIRTHDAYS; WITH RATE OF GROWTH ESTIMATED BY USING AS BASE THE INCREMENT DURING THE FIRST YEAR OF THE PERIOD OF MEASUREMENT, DIVIDING THE INITIAL YEAR'S INCREMENT INTO THE INCREMENT OF EACH FOLLOWING YEAR

Function Measured	Group I Ratios for 12 Boys Measured from the 8th through the 12th Birth- days, with the Base the Increment between the 8th and the 9th				Group II Ratios for 20 Boys Measured from the 9th through the 13th Birth- days, with the Base the Increment between the 9th and the 10th			
	8-9	9-10	10-11	11-12	9-10	10-11	11-12	12-13
Psychological . .	100	117.6	143.1	201.1	100	110.9	124.1	109.0
Standing Height .	100	96.4	94.9	86.5	100	94.8	92.5	123.7
Sitting Height .	100	130.9	57.3	70.9	100	76.8	80.3	100.5
Weight	100	103.4	128.9	96.9	100	146.2	157.9	166.0
Ossification Ratio	100	115.4	112.1	126.4	100	124.5	121.3	122.6
Chest Girth . . .	100	98.4	93.8	69.8	100	112.2	155.1	109.0
Lung Capacity . .	100	72.6	91.1	115.7	100	79.2	97.1	124.1
Function Measured	Group III Ratios for 35 Boys Measured from the 10th through the 14th Birth- days, with the Base the Increment between the 10th and the 11th				Group IV Ratios for 39 Boys Measured from the 11th through the 15th Birth- days, with the Base the Increment between the 11th and the 12th			
	10-11	11-12	12-13	13-14	11-12	12-13	13-14	14-15
Psychological . .	100	129.2	108.2	83.2	100	77.2	75.5	61.2
Standing Height .	100	103.6	128.8	154.3	100	124.0	148.0	123.1
Sitting Height .	100	108.9	133.8	169.5	100	154.3	193.9	151.5
Weight	100	113.9	145.8	156.8	100	120.8	131.4	141.8
Ossification Ratio	100	120.1	119.8	103.9	100	111.8	92.2	59.7
Chest Girth . . .	100	223.3	211.9	361.3	100	75.1	166.5	141.6
Lung Capacity . .	100	192.6	286.7	372.7	100	118.9	183.7	176.0
Function Measured	Group V Ratios for 32 Boys Measured from the 12th through the 16th Birth- days, with the Base the Increment between the 12th and the 13th				Group VI Ratios for 40 Boys Measured from the 13th through the 17th Birth- days, with the Base the Increment between the 13th and the 14th			
	12-13	13-14	14-15	15-16	13-14	14-15	15-16	16-17
Psychological . .	100	82.4	75.7	70.0	100	86.4	87.1	78.8
Standing Height .	100	106.3	99.1	71.6	100	82.9	56.8	28.8
Sitting Height .	100	122.5	125.4	83.2	100	87.4	77.5	53.6
Weight	100	115.2	131.0	111.7	100	109.8	86.8	54.2
Ossification Ratio	100	96.8	58.8	51.1	100	68.6	48.5	51.5
Chest Girth . . .	100	105.8	155.4	138.2	100	98.9	81.8	61.9
Lung Capacity . .	100	130.7	163.7	131.6	100	76.2	95.9	56.0

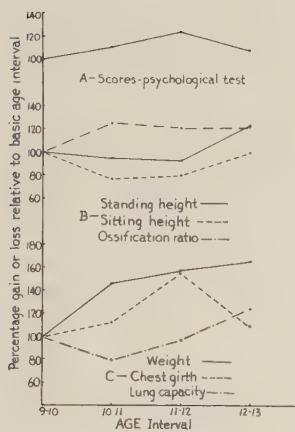


Figure 5a

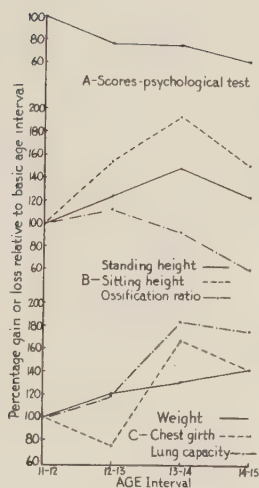


Figure 5b

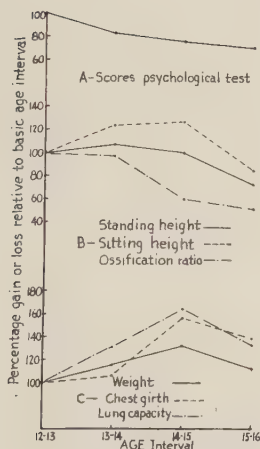


Figure 5c

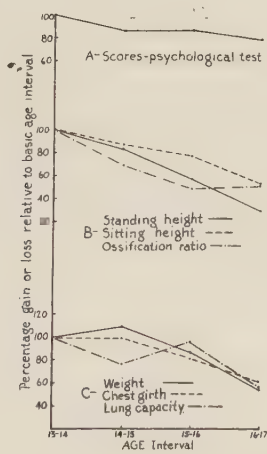


Figure 5d

Figure 5.- Rate of growth in various traits for four groups of boys, each group measured for five consecutive birthdays. (Data for these curves are given in Table X.)

of growth, of any type of relation between minor fluctuations in mental and physical development. The only positive evidence of correlation with relative maturity is that found in the trend of decreasing coefficients between the mental and physical measures during late adolescence (Chapter III). It seems from the data of the study that if there does exist a relationship between rate of mental and physical development, it must be more general than a correlation between variations in growth rate.

CHAPTER V

VARIABILITY IN MENTAL AND PHYSICAL MEASURES IN SUCCEEDING AGES

Problems

The techniques applied in phases of the study previously summarized have failed to give any evidence of relationship between periods of change in rate of mental and physical growth. In the present chapter, further attack is made upon this problem through consideration of curves of variability in mental and physical measures. Marked changes in variability from age to age have in some instances been found associated with changes in rate of growth. Curves of variability in mental and physical measures are, therefore, of possible significance in the study of the problem of relationship between rate of mental and physical growth.

Investigations of physical growth agree in the finding of increasing variability in most physical traits during the early years of adolescence.¹ This trend of physical development is revealed whether the measure of variability employed be in the absolute units of the variable, as in the standard deviation, or in terms of variation relative to the mean. Dr. Herman G. Richey has recently compared curves of absolute increments in height and weight with curves of variability for the same data.² He finds that variability, absolute or relative, increases as long as the growth rate of the group as a whole is positively accelerated. A decline in variability accompanies a falling off in the growth rate. Dr. Richey's explanation of this decline in variability during late adolescence is that heterogeneity in a trait for a group gradually diminishes after a portion of the group reaches the maximum, because others who have not reached such a point continue to grow.

The literature on comparative variability in intelligence at different ages, unlike similar studies of physical development, shows considerable disagreement. Differences in the results of such studies seem to be due to differences in the following factors: (1) the type of test employed; (2) the method of treating test results--for example, whether the data are used in raw units or submitted to a scaling device; and (3) the measure of

¹ Henmon, in a study based upon data reported from extensive investigations of mental and physical development, has compared variabilities at different ages in both mental and physical measurements. Variabilities in the height and weight of boys were found to be greatest between thirteen and one-half and fifteen and one-half years. The investigations summarized differed somewhat as to the exact year of the peak. The highest point of variability was found to occur about two years earlier for girls than for boys. The measurements of lung capacity showed no evidence of greater variability during these years. Henmon's measure of variability was the coefficient of variation. (V. A. C. Henmon, "Comparative Variability at Different Ages," *Journal of Educational Psychology*, XIII (1922), 17-29.) Henmon's conclusions concerning variability in height and weight have been confirmed in a recent careful study by Gray and Ayres. These investigators have reported, from a study of body growth of children, that pubertal increase in variability occurs about age twelve in girls and fourteen in boys. (Horace Gray and J. G. Ayres, *Growth in Private School Children*. Chicago: University of Chicago Press, 1931. Pp. xv + 282.)

² A study of height and weight now in progress. The data are from the University of Chicago Laboratory Schools.

variability used.³ Certain results of the present study, to be described in this chapter, suggest that the average level of intelligence of the group of subjects tested is another factor in the determination of the character of changes in variability in succeeding ages.

The present chapter deals with changes in variability in succeeding ages, from the point of view of the general problem of determining mental and physical relationships. Comparative analysis is made of curves of variability in mental-test scores and in the various physical traits selected. The problem of relation between rate and level of the growth curves, both mental and physical, is considered. There are two main parts of the chapter. The first deals with curves of variability based upon measures for all subjects. In these data, it may be remembered, there is overlapping of populations from age to age, since the mean number of repeated birthday examinations is five. The second part of the chapter is devoted to a more detailed analysis of the data for groups of boys and girls constant in population for seven consecutive birthday tests. It is in the study of these continuous groups that there is the possibility of raising the question of relation of level of ability to rate of development. In the case of boys, variations in rate of mental development for groups of different ability-levels may also be compared with variations in rate of growth in standing height for the same groups. The measures of standing height for girls were not sufficiently complete for this comparison to be made.

The Data

Curves of variability for all cases.— Absolute and relative measures of variability at each age for all subjects tested are given in Table VII, Chapter III. Figure 6, which appears in the present chapter, shows curves of standard deviations for boys and girls in the mental-test scores and in measures of standing height, sitting height, and weight. Figure 7 shows curves of relative variability derived from the same data.

Comparison of the curves of variability in mental and physical traits reveals significant differences. The standard deviations in physical traits follow curves very closely related to the growth curves presented in Chapter III. During the period of rapid growth in a physical trait, the standard deviations increase markedly. The point of slowing down in growth rate is also correlated with the point of decline in standard deviations. In each of the physical measures, the curves of absolute variability for girls are above the curves for boys prior to the period of positive acceleration in the growth rate of boys. In late adolescence, absolute

³ Henmon (op. cit.) concluded from his application of the coefficient of variation to mental-test data, that variability in mental traits decreases with age from childhood to adulthood. Henmon's tables show, however, that for the data summarized variation expressed in absolute units increases during adolescence. Johnson used two forms of the Chicago Group Intelligence Test in his retests of high-school students, and obtained results fairly similar to those reported by Henmon. Johnson found increase in variability during the high-school period when the standard deviation was the measure of variation, but no general evidence of this increased variability appeared when the coefficient of variation was used. (William H. Johnson, "The Mental Growth Curve of Secondary School Students," pp. 119-26. Unpublished Doctor's thesis, Dept. of Education, University of Chicago, 1923). Freeman has analyzed the data assembled by Henmon and by others. His study of the problem indicates that both the type of mental test employed and the measure of variability are significant factors in determining the character of changes in variability from age to age. (Frank N. Freeman, Mental Tests, Chapter XIII. Boston: Houghton Mifflin Co., 1926). Thurstone has applied his method of scaling test results to Burt's data for the Binet tests (L. L. Thurstone, "A Method of Scaling Psychological and Educational Tests," Journal of Educational Psychology, XVI (1925), 433-51), and to the mental ages of institutional cases (*ibid.*, "The Mental Growth Curve for the Binet Tests," Journal of Educational Psychology, XX (1929), 569-83). Thurstone concludes from his two studies that absolute variability of test-intelligence increases with age until adult intelligence is attained. Odom has applied Thurstone's method of scaling to data from group intelligence tests and has reported findings in agreement with those of Thurstone. (Charles L. Odom, "A Study of the Mental Growth Curve with Special Reference to the Results of Group Intelligence Tests," Journal of Educational Psychology, XX (1929), 401-406.)

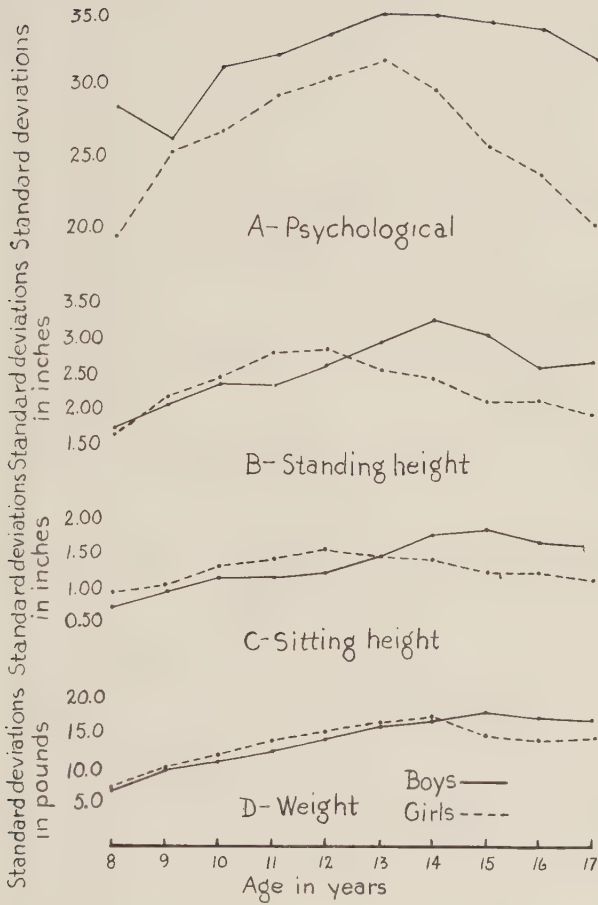


Figure 6.- Standard deviations in psychological-test scores, standing height, sitting height, and weight; data for all subjects. (The data from which these curves are drawn are given in Table VII, Chapter IV.)

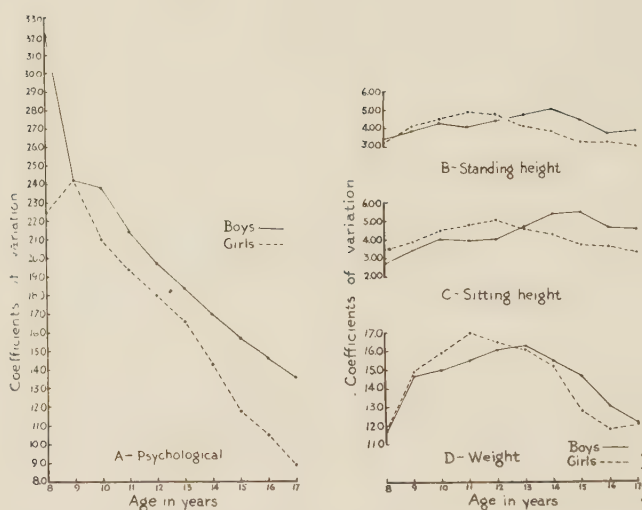


Figure 7.- Coefficients of variation in psychological-test scores, standing height, sitting height, and weight; data for all subjects. (The data from which these curves are drawn are given in Table VII, Chapter IV.)

variability in the physical measures is greater for boys than for girls of the same age. When variability is measured in relation to the mean by the coefficient of variation, there is again evidence of increased variability during the period of acceleration in physical growth. In the mental-test scores, on the other hand, boys exceed girls in the standard deviations at any given age. There is increase in variability until age thirteen for both sexes, with the rate of increase between the tenth and thirteenth birthdays approximately the same for boys and girls. Following the thirteenth birthday, there is a slight decline in the standard deviations of boys and a marked loss for girls. The curves of coefficients of variation in mental-test scores differ, likewise, from those in physical measures. There is a decline in variability in the psychological scores in succeeding ages when the measure is related to the mean. Relative, like absolute variability, is greater for boys than for girls.⁴

Curves of variability for continuous groups.— Data from this point in the present chapter are for 42 boys and 42 girls measured by the psychological test for seven consecutive birthdays, beginning with the tenth and ending with the sixteenth. Complete records of measures of standing height for this period were available in the case of boys. The problem of the divergence of growth curves is attacked through the differentiation of subgroups of boys and girls on the basis of rank in the mean of psychological-test scores at ages twelve, thirteen, and fourteen--the middle years of the period of measurement. The data for boys are further analyzed through comparison of growth curves and of curves of variability in mental and physical measures.

Table XI shows the mean psychological scores for boys and girls grouped with regard to level of psychological scores.

TABLE XI

AVERAGE PSYCHOLOGICAL SCORES FROM AGE TEN THROUGH SIXTEEN
FOR GROUPS OF BOYS AND GIRLS DIFFERENT IN LEVEL
OF TEST SCORES

Group		Number of Cases	Mean of Psychological Scores at Age						
			10	11	12	13	14	15	16
Boys	High	14	164.9	194.3	214.1	234.4	245.9	263.2	281.5
	Middle	14	128.6	153.3	176.2	198.1	214.9	234.1	250.4
	Low	14	104.6	122.7	140.9	159.5	179.6	201.1	221.3
Girls	High	14	152.5	176.0	203.6	224.4	242.8	259.0	273.6
	Middle	14	117.9	149.1	172.1	192.1	208.4	221.6	233.9
	Low	14	111.6	137.8	146.5	167.6	189.7	207.8	223.4

Table XII gives differences in test scores at each age for certain contrasted groups. The group differences increase until twelve or thirteen, then decrease. Figure 8 shows the mental-growth curves of boys of different levels of test intelligence. In Figure 9 are presented similar curves for girls. Divergence of the curves is more marked in the case of boys. It is evident, however, that for both sexes the group lowest in the test scores has the least negative acceleration in the mental-growth curve during the period of measurement. Indeed, the curve of the lowest level of

⁴ Henmon (op. cit.) computed ratios of the variability of girls to that of boys. His results for the mental-test scores seem, in general, to show a greater variability among the boys, but there are irregularities. Terman has reported inconsistency in mental-test data bearing on sex variability. (Lewis M. Terman and Others, *Genetic Studies of Genius*, Vol. I, 53-54. Stanford University, California: Stanford University Press, 1925.)

TABLE XII

DIFFERENCES IN AVERAGE PSYCHOLOGICAL SCORES AMONG GROUPS
OF SUBJECTS DIFFERENT IN LEVEL OF TEST SCORES

Groups Contrasted		Differences in Mean Scores at Age						
		10	11	12	13	14	15	16
Boys	High and Low	60.3	71.6	73.2	74.9	66.3	62.1	60.2
	Middle and Low	24.0	30.6	35.3	38.6	35.3	33.0	29.1
Girls	High and Low	40.9	38.2	57.1	56.8	53.1	51.2	50.2
	Middle and Low	6.3	11.3	25.6	24.5	18.7	13.8	10.5

boys is slightly positively accelerated. Apparently the group that develops at first most slowly in intelligence tends to catch up with the other groups. Differences in intelligence would very probably be less at adulthood than at sixteen.⁵

An important phase of the problem of growth relationships may now be considered: Does that part of the group which matures most rapidly in intelligence tend also to develop most rapidly physically? Growth curves in height have been selected for the present phase of the investigation because of the consistent positive correlation of height with the mental-test scores. Table XIII shows that for the groups of boys under consideration, the rank in the mental-test scores is directly related to rank in height. The data in Table XIII are presented graphically in Figure 10. It is evident that the three intelligence-level groups have approximately the same rate of growth in height throughout the six-year period. Group differences in rate of mental development, as measured by the test, are not correlated with differences in rate of growth in height.

The measures of variability for the three groups of boys tend to confirm the conclusion that variations in mental- and physical-growth rate are unrelated. Tables XIV-XVII show standard deviations and coefficients of variation in psychological scores and standing height at each age for each of the three groups of boys classified according to intelligence-test level. Tables XVIII and XIX give similar data for the composite group. Curves of standard deviations drawn from these tables appear in Figure 11; curves of deviations in relation to the mean, in Figure 12.

The curve of standard deviations in psychological scores for the composite group is fairly similar to that for all boys in Figure 6. Curves in absolute variability for sub-groups show interesting differences. If the curves for these groups were smoothed, the standard deviations for the group low in intelligence would show a fairly straight line ascending, while the curve for the high group would show a descending line. These

⁵ Baldwin reported a divergence of the mental-growth curves of superior and average children. His data consist of mental ages secured through the repeated examination of children from age five through fourteen. (Bird T. Baldwin and Lorle I. Stecher, Mental Growth Curve of Normal and Superior Children Studied by Means of Consecutive Intelligence Examinations. University of Iowa Studies in Child Welfare, Vol. II, No. 1, pp. 10-11. Iowa City: University of Iowa Press, 1922). Jordan, however, has followed Baldwin's technique and has found curves of different I.Q. levels approximately parallel. (A. M. Jordan, "Mental Growth," Journal of Applied Psychology, XIV (1930), 517-31.) Freeman (op. cit.) and Thurstone ("The Mental Growth Curve for the Binet Tests," Journal of Educational Psychology, XX (1929), 569-83) have studied large bodies of data with different results. Freeman has found that the mental-growth curves of children different in level of intelligence, as measured by well standardized group tests, are fairly parallel when such data are plotted in raw units. Thurstone's results from scaling mental ages, on the other hand, show a mental-growth curve for bright children which approaches the level of test maturity sooner than that of dull children. Thurstone has concluded that it is quite probable that bright children reach the inflection point in their growth curves sooner than dull children.

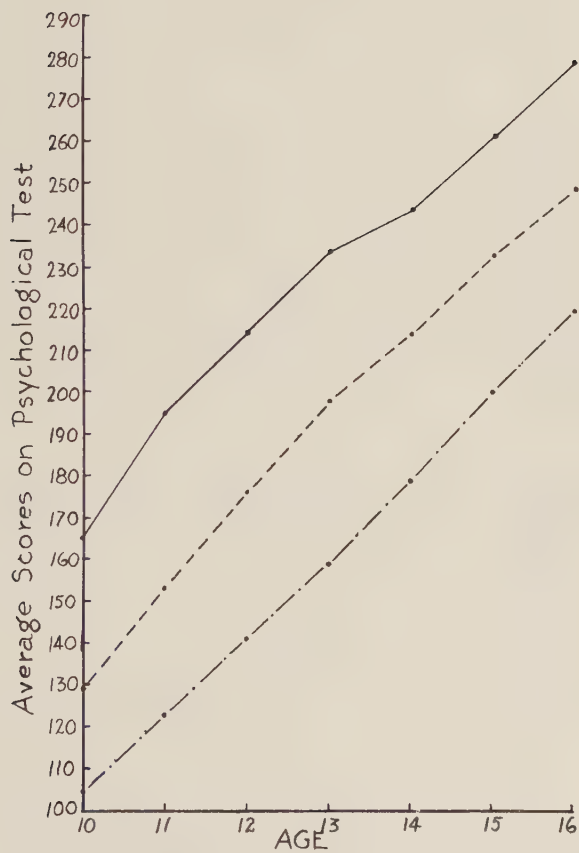


Figure 8.- Mental-growth curves of groups of boys different in level of psychological-test scores.

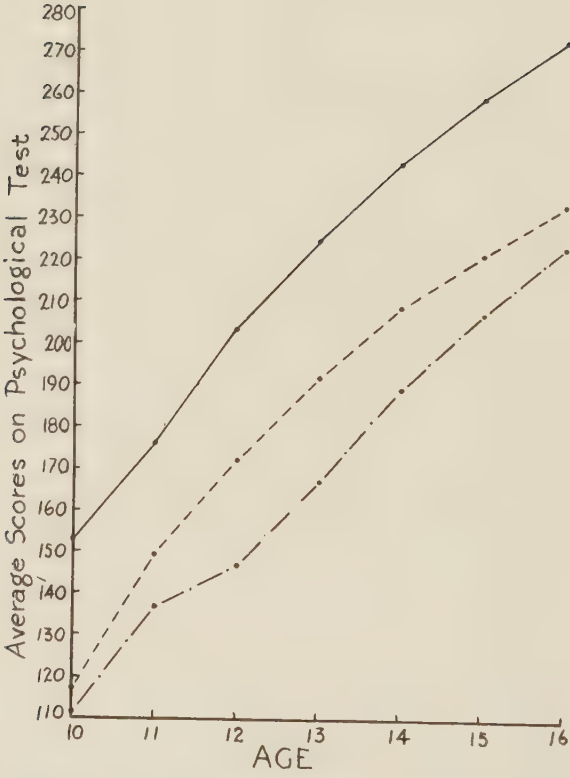


Figure 9.- Mental-growth curves of groups of girls different in level of psychological-test scores.

TABLE XIII

AVERAGE MEASURES OF STANDING HEIGHT FOR THE THREE GROUPS OF BOYS
DIFFERENT IN LEVEL OF PSYCHOLOGICAL-TEST SCORES

Rank of Group in Psychological- Test Scores	Mean Height in Inches at Age						
	10	11	12	13	14	15	16
High	55.7	57.9	60.1	62.8	65.9	68.2	69.7
Middle	55.4	57.4	59.7	62.4	65.4	67.9	69.5
Low	54.1	56.0	58.0	60.8	63.5	65.8	67.7

TABLE XIV

STANDARD DEVIATIONS IN PSYCHOLOGICAL SCORES FOR THE THREE GROUPS
OF BOYS DIFFERENT IN LEVEL OF PSYCHOLOGICAL-TEST SCORES

Rank of Group in Psychological- Test Scores	Standard Deviations at Age						
	10	11	12	13	14	15	16
High	20.27	20.19	20.18	13.04	17.71	16.57	16.58
Middle	10.77	12.04	15.05	7.71	15.01	20.05	16.82
Low	12.08	16.53	16.06	20.19	20.75	18.93	23.59

TABLE XV

STANDARD DEVIATIONS IN STANDING HEIGHT FOR THE THREE GROUPS OF
BOYS DIFFERENT IN LEVEL OF PSYCHOLOGICAL-TEST SCORES

Rank of Group in Psychological- Test Scores	Standard Deviations in Standing Height in Inches at Age						
	10	11	12	13	14	15	16
High	1.19	1.32	1.45	1.77	2.08	2.01	1.84
Middle	2.23	2.19	2.72	3.46	3.66	3.37	3.10
Low	2.07	2.17	2.64	3.17	3.81	3.64	2.82

TABLE XVI

VARIABILITY IN PSYCHOLOGICAL SCORES GIVEN IN COEFFICIENTS OF
VARIATION FOR THE THREE GROUPS OF BOYS DIFFERENT
IN LEVEL OF PSYCHOLOGICAL-TEST SCORES

Rank of Group in Psychological- Test Scores	Coefficients of Variation at Age						
	10	11	12	13	14	15	16
High	12.29	10.39	9.43	5.56	7.20	6.30	5.89
Middle	8.37	7.85	8.54	3.89	6.98	8.56	6.72
Low	11.55	13.47	11.39	12.66	11.55	9.41	10.66

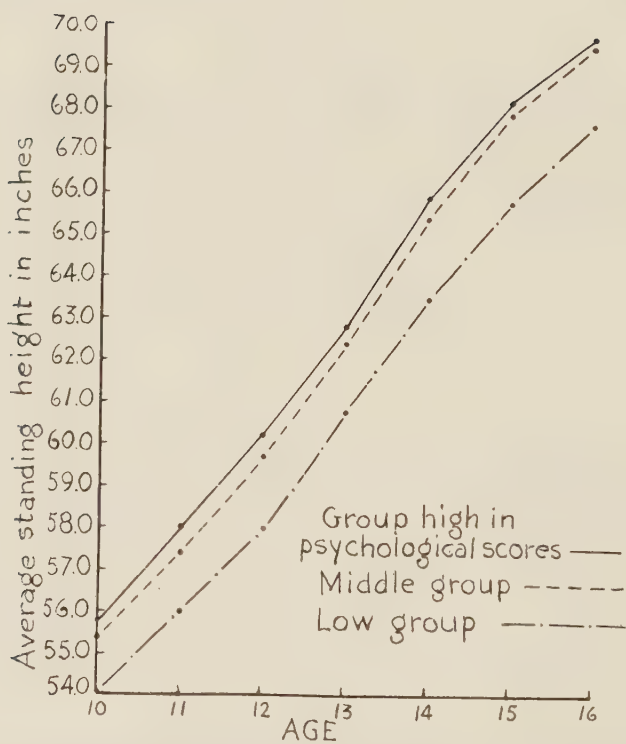


Figure 10.- Growth curves in standing height for boys of different intelligence levels.

TABLE XVII

VARIABILITY IN STANDING HEIGHT GIVEN IN COEFFICIENTS OF
VARIATION FOR THE THREE GROUPS OF BOYS DIFFERENT IN
LEVEL OF PSYCHOLOGICAL-TEST SCORES

Rank of Group in Psychological- Test Scores	Coefficients of Variation at Age						
	10	11	12	13	14	15	16
High	2.14	2.28	2.41	2.82	3.16	2.95	2.64
Middle	4.03	3.82	4.56	5.54	5.60	4.96	4.46
Low	3.83	3.88	4.55	5.21	6.00	5.53	4.17

TABLE XVIII

MEANS, STANDARD DEVIATIONS, AND COEFFICIENTS OF VARIATION IN
PSYCHOLOGICAL SCORES FOR THE COMPOSITE OF THE
THREE GROUPS OF BOYS

Age	10	11	12	13	14	15	16
Mean	127.4	154.1	174.1	194.7	213.6	229.5	243.6
Standard Devia- tion	29.08	34.28	34.67	33.77	33.46	32.24	30.66
Coefficient of Variation . .	22.83	22.25	19.91	17.34	15.66	14.04	12.59

TABLE XIX

MEANS, STANDARD DEVIATIONS, AND COEFFICIENTS OF VARIATION IN
STANDING HEIGHT FOR THE COMPOSITE OF THE
THREE GROUPS OF BOYS

Age	10	11	12	13	14	15	16
Means in Inches	55.1	57.1	59.3	62.0	64.9	67.3	69.0
Standard Deviation . .	2.09	2.12	2.51	3.11	3.49	3.40	2.80
Coefficient of Varia- tion	3.79	3.71	4.23	5.02	5.38	5.05	4.06

curves are in harmony with the trend of the mental-growth curves for the same groups (Figure 8). The high group has a negatively accelerated course of development, while the low group follows a fairly straight line. The curve of the middle group is less negatively accelerated, in its general course, than that of the high group. The curves of standard deviations in height, on the other hand, do not differ in form. The peak occurs at the same age, the fourteenth year, for the entire group and for each sub-group; and the bell-shaped curve is found in every case. The curves of variability in relation to the mean (coefficients of variation) are fairly similar to the curves of standard deviations, except for the marked decline from age to age in the coefficients of variation of psychological scores for the group as a whole.

Summary

Marked changes in variability from age to age have been related by some students of child development to changes in rate of growth. This relation is very evident in studies of physical growth and probably holds also in mental development, although the problem is complicated by many factors

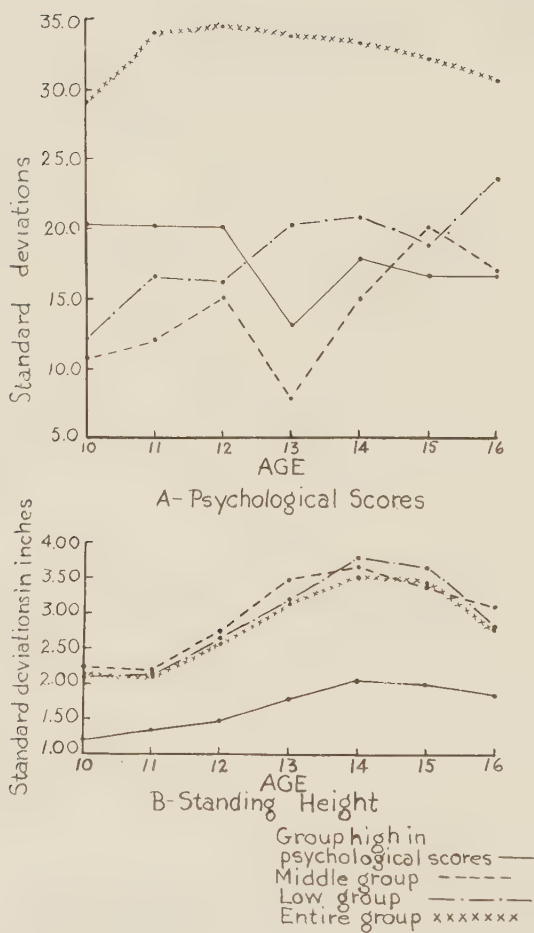


Figure 11.- Curves of absolute variability in psychological scores and standing height. (The curves are drawn from data for the entire group of 42 boys and for each of the three intelligence-level divisions.)

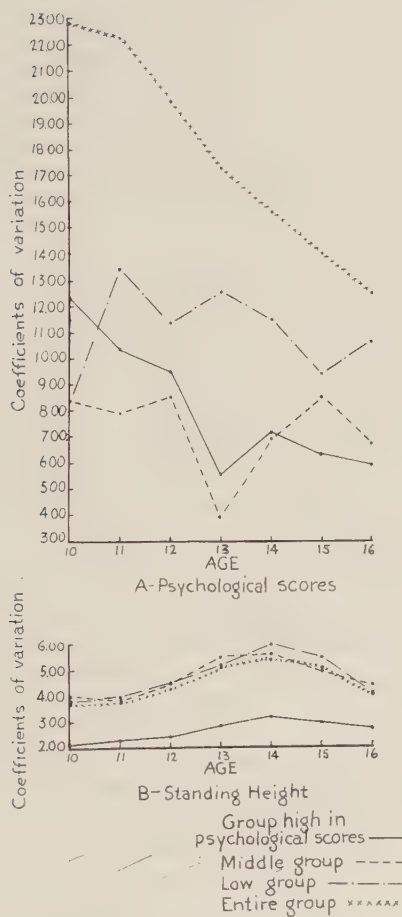


Figure 12.- Curves of relative variability in psychological scores and standing height. (The curves are drawn from data for the entire group of 42 boys and for each of the three intelligence-level divisions.)

when mental measurement is involved. Data presented in this chapter suggest that variations in rate of mental growth are unrelated to variations in rate of physical growth. Measures of absolute variability and of variability in relation to the mean are given for boys and girls separately at each age from the eighth birthday through the seventeenth. The curves of variability in the physical traits differ in many respects from those based upon the mental-test data. More striking differences between curves of variability in mental and physical traits appear when a group of 42 boys measured for seven consecutive birthdays is divided into three groups on the basis of rank in mental-test scores. Both the mental-growth curves and curves of variability indicate that the groups thus selected are different in rate of mental maturing. Individuals of higher level in ability tend to a somewhat more rapid rate of maturing. Similar analysis of measures of standing height for these groups reveals no evidence of group differences in rate of growth in height, although there is positive relationship at each age between measures of height and mental-test scores.

If the results which appear in this chapter were considered in isolation, they might be interpreted as indicating that the correlation between the intelligence-test scores and the physical measures, a relationship demonstrated in Figure 10, is one of level, i.e., permanent status, rather than a correlation in rate of development. Certain data which appear in Chapters III and VII suggest, however, different conclusions. It was shown in Chapter III, Tables I-III, that there is a decline in correlation between mental and physical measurements during late adolescence, a trend marked in the coefficients for girls by age sixteen, but not consistently apparent in those for boys by that age. Unfortunately, the data available do not show us for the groups of boys studied in this chapter, the form of the curves of height (Figure 10) after age sixteen, and the physical data for the continuous groups of girls are not complete. A cross section at an upper age level is given, however, in the results for college students (Chapter VII). These data suggest that there is no relationship between the mental and physical status of mature individuals, a conclusion supported by references to other investigations. If the height curves of the different ability groups (Figure 10) could be extended to maturity, it seems probable that the differences in level of height would disappear.

The data of the present chapter are in harmony with previous findings which indicate that fluctuations in rate of mental and physical growth are unrelated. If there is any correlation in rate of maturing, it is apparently of the more general type suggested in the preceding paragraph.

CHAPTER VI

THE RELATION OF AGE OF PUBESCENCE TO MENTAL GROWTH

Previous Studies of the Relation of Age of Pubescence to Physical and Mental Development

Some students of child development have held that the age of onset of puberty is the most important index of general maturing, either physical or mental. Such a position has been emphasized by Crampton,¹ by Baldwin,² and by Godin.³ The most convincing evidence of the relation of age of pubescence to rate of development in physical traits is in the recent statistical treatment of the problem by Richey.⁴ Richey has correlated age of pubescence with blood pressure, height, weight, chest girth, ossification ratio, and lung capacity. Report of the coefficients of correlation between these various physical characters has been supplemented in his work by a comparative study of the physical-growth curves of groups of girls differentiated on the basis of age of pubescence. There is striking evidence from this investigation that children different as to precocity of sexual maturing are different also in rate of anatomical and physiological development. The relationship is positive, and is evident from the earliest age studied by Richey--age six. Differences between maturity groups persist to the end of the adolescent period in some traits, but differences in height are not found after the fourteenth year.

Interest in the relationship between physiological age and intelligence was marked in the work of Crampton. Using school standing as the criterion of intelligence, and comparing prepubescents with postpubescents, Crampton found slight differences in favor of the postpubescents.⁵ Somewhat similar studies by Foster⁶ and by King⁷ have likewise suggested a very low positive relationship between school success and precocity of pubescence. A direct correlational study of the problem has been reported by the writer. Correlation of mental age with age of pubescence for each of four chronological-age groups, ages fourteen through seventeen, yielded negative results. However, the number of subjects in each group considered was so small that the evidence is not conclusive. The writer found marked differences in the school success of two groups of girls--one group exceptionally precocious in age of physiological maturing; the other, exceptionally retarded. The retarded group was definitely lower than the precocious, on the average, in grade location and in other measures of school success.⁸ A correlation

¹ C. Ward Crampton, "The Influence of Physiological Age upon Scholarship," Psychological Clinic, I (1907), 115-20. Ibid., "Anatomical or Physiological Age versus Chronological Age," Pedagogical Seminary, XV (1908), 230-37. Ibid., "Physiological Age--A Fundamental Principle," American Physical Education Review, XIII (1908), 141-54, 214-27, 268-83, 345-58.

² Bird T. Baldwin, The Physical Growth of Children from Birth to Maturity. University of Iowa Studies in Child Welfare, Vol. I, No. 1, 188-236. Iowa City, Iowa: The University of Iowa Press, 1921.

³ Paul Godin, Growth during School Age (Translation by Samuel L. Eby), pp. 66-103. Boston: The Gorham Press, 1920.

⁴ Herman Glenn Richey, "The Blood Pressure in Boys and Girls before and after Puberty," American Journal of Diseases of Children, XLII (1931), 1281-1330.

⁵ C. Ward Crampton, "The Influence of Physiological Age Upon Scholarship," Psychological Clinic, I (1907), 115-20.

⁶ Wilfred L. Foster, "Physiological Age as a Basis for the Classification of Pupils Entering High School--Relation of Pubescence to Height," Psychological Clinic, IV (May, 1910), 83-88.

⁷ Irving King, "Physiological Age and School Standing," Psychological Clinic, VII (January, 1914), 222-29.

⁸ Ethel M. Abernethy, "Correlations in Physical and Mental Growth," Journal of Educational Psychology, XVI (1925), 458-66; 539-46.

study similar to that of the writer was conducted by Viteles with 236 young women as subjects. The results are likewise negative.⁹ Viteles' study, however, was of girls near the close of the adolescent period and is not directly comparable with data concerning subjects measured during the period of growth.

The mental-growth curves obtained from some investigations have shown positive acceleration during some phase of the period of early adolescence. Baldwin's mental-growth curves, based upon data secured from successive examinations, have slight acceleration between the ages of eleven and fourteen. This rise in the curves was ascribed by Baldwin to "prepubertal increase" in mental ability.¹⁰ Murdock and Sullivan have reported data from group tests administered to 580 boys and girls who ranged in age from six to eighteen years. The results of their investigation are interpreted as furnishing evidence that a pre-adolescent increase in rate of mental growth occurs at the same time in the development of each sex that the physical acceleration occurs. The acceleration in mental growth is, however, less than that in the physical traits measured, and the authors' conclusions are given as tentative interpretations.¹¹ Johnson concluded from his retests of high-school students that there is "distinct evidence of an 'adolescent spurt' following the twelfth or thirteenth year for girls and the fourteenth or fifteenth for boys."¹²

Present Data

The present study of pubescence in relation to mental growth considers four methods of approach to the general problem. First, boys and girls grouped on the basis of age of physiological maturity are compared for each sex and sign of pubescence in regard to curves of mental growth. The second attack on the problem is through the computation of the coefficients of correlation between precocity of pubescence and psychological scores at various ages. In the third place, selection has been made of individuals for whom pubescence occurred about the middle of the period of repeated measurements, and individual growth curves have been constructed with a view to presenting the effect of onset of puberty upon the mental-growth curve, in comparison with the effect of this event upon growth in general physical traits. Finally, the 33 girls studied individually have been assembled into four groups approximately homogeneous in age of maturing, and curves of growth in intelligence, height, and weight are presented for these groups.

Mental-growth curves of different maturity groups.— Cumulative records from the annual mental and physical examinations of the children in the Laboratory Schools have made possible the construction of the curves which appear in Figures 13-15. A child may be measured by the psychological test prior to the age of pubescence, subsequent to it, or both before and after puberty. In the annual physical examination, note is made of the absence or presence of signs of puberty, and this record is permanent in the files.

Differences in the mental-growth curves of three maturity groups of

⁹ Morris S. Viteles, "The Influence of Age of Pubescence upon the Physical and Mental Status of Normal School Students," Journal of Educational Psychology, XX (1929), 360-68.

¹⁰ Bird T. Baldwin and Lorle I. Stecher, Mental Growth Curve of Normal and Superior Children Studied by Means of Consecutive Intelligence Examinations, University of Iowa Studies in Child Welfare, Vol. II, No. 1, pp. 12-14. Iowa City: University of Iowa Press, 1922.

¹¹ Kathryn Murdock and Louis R. Sullivan, "Some Evidence of an Adolescent Increase in the Rate of Mental Growth," Journal of Educational Psychology, XIII (1922), 350-56.

¹² William H. Johnson, "The Mental Growth Curve of Secondary School Students," pp. 111-18. Unpublished Doctor's thesis, Dept. of Education, University of Chicago, 1923.

TABLE XX

AVERAGE SCORES ON PSYCHOLOGICAL TEST FROM AGE NINE THROUGH SIXTEEN FOR GIRLS OF THREE MATURITY GROUPS

Age	Period of Pubescence								
	Before 13th birthday			Between 13th and 14th birthdays			After 14th birthday		
	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
9 .	23	112.6 ± 3.7	26.3	10	101.7 ± 4.9	22.9			
10 .	35	137.4 ± 3.1	27.2	18	125.7 ± 3.6	22.9	8	119.8 ± 3.3	13.7
11 .	52	156.5 ± 2.8	29.5	21	149.3 ± 4.0	27.5	12	142.0 ± 4.8	24.4
12 .	56	175.4 ± 2.7	30.3	24	172.1 ± 3.7	27.2	14	165.8 ± 3.9	21.4
13 .	49	198.1 ± 3.3	34.1	25	190.6 ± 3.4	25.4	18	184.6 ± 3.6	22.7
14 .	44	213.5 ± 3.4	33.7	25	208.7 ± 3.1	22.6	21	200.6 ± 2.9	19.6
15 .	36	225.7 ± 3.3	29.5	22	220.0 ± 3.0	20.6	20	212.1 ± 3.4	22.5
16 .	25	229.3 ± 4.3	32.0	14	227.6 ± 2.2	12.5	15	219.8 ± 2.4	13.9

girls¹³ may be observed from Table XX and Figure 13. The curves of the three groups are surprisingly smooth, considering the small number of subjects in each group. Girls of different maturity groups are different in psychological scores at all ages for which data are available. There is significance in the fact that the curves are almost exactly parallel throughout the period of adolescence. If acceleration does occur about the time of puberty, it seems that it would be noticeable in these curves for groups so nearly homogeneous in the ages of maturity. Especially might it be expected of the middle group, which has a range of only one year in age of onset of puberty. But there is no evidence of change in growth rate because of this physiological event. It is very probable that puberty does not mark an abrupt change. Physiological maturation is established throughout a period of years, and differences in rate of development in this function probably exist from very early childhood. Consideration of the present data in relation to results of similar analysis of records for young women (Chapter VII, Table XXX) suggests that rate of physiological maturing is positively related to rate of mental development. It is true that differences in rate of mental maturing are not apparent for the physiological groups within the age limits of the Laboratory-School study, as Figure 13 shows; if these fairly parallel curves were considered without reference to later phases of the study, it might be concluded that the groups differ in level (permanent status), not in rate of mental development. But the finding at adulthood of no relationship between the mental-test scores and age of occurrence of puberty leads necessarily to the hypothesis that the groups different in rate of physiological maturing differ also in rate of mental growth, and that this differentiation must have occurred at an earlier age than is made available for study by the present data. Richey's data give evidence of correlation between physiological and anatomical maturing.¹⁴ The present study indicates that there is a

¹³ The average age of puberty for these subjects is slightly before the thirteenth birthday. Since in some of the records only the year of the occurrence was given, it was impossible to divide the groups in such a way that the largest number of cases would fall into the middle one.

¹⁴ H. G. Richey, *op. cit.*

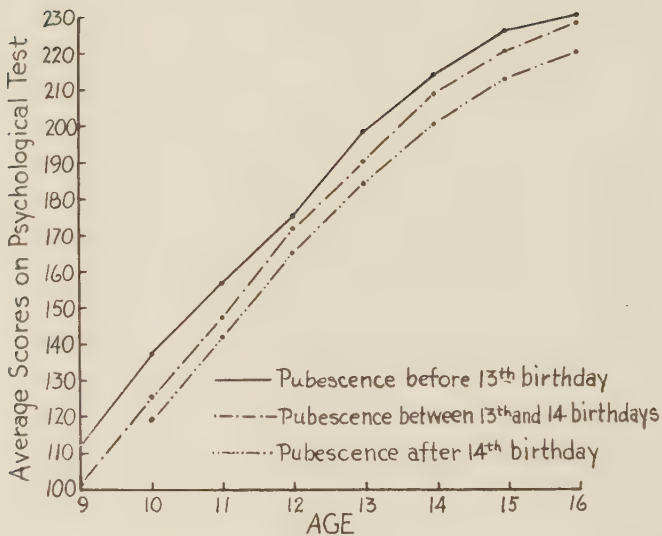


Figure 13.- Average scores on the psychological test for girls of different maturity groups. (Basis of graph, the means of Table XX.)

similar relationship between physiological and mental development.¹⁵

Similar data for boys are given in Tables XXI-XXIII, and in Figures 14 and 15. The four groups of boys differentiated on the basis of the first sign of pubescence (pubes), show no overlapping in the means of psychological scores except at two ages in the central groups; in the three groups differentiated according to age of appearance of the second sign (axillary hair), there is no overlapping before the sixteenth year. The differences between maturity groups are not statistically significant, as Table XXIII shows for the groups most widely different in psychological scores; however, the general consistency of the data for both boys and girls seems to overshadow the relatively large probable errors of the differences.

Correlational study of the data.— Correlation coefficients present a more exact measure of the amount of relationship between traits than do averages. Table XXIV shows the correlation of precocity of pubescence with psychological scores at various ages.¹⁶ The coefficients are positive at every given age. The degree of relationship is approximately the same as the general trend of the correlations between the physical traits and the measure of intelligence. The correlation coefficients are too low to justify at any age the prediction of an individual's rating in intelligence from knowledge of age of pubescence. It is evident, however, that children who mature earlier than the average are, in general, somewhat overestimated in regard to intelligence, while those who are late in maturing tend to be underestimated.¹⁷

TABLE XXI

AVERAGE SCORES ON PSYCHOLOGICAL TEST FROM AGE NINE THROUGH SEVENTEEN
FOR BOYS OF FOUR MATURITY GROUPS, WITH PUBES THE CRITERION

Age	Period of Pubescence											
	Group I Before 12th birth- day			Group II Between 12th and 13th birthdays			Group III Between 13th and 14th birthdays			Group IV After 14th birthday		
	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
9	8	129.8 ± 5.8	24.3	15	105.9 ± 2.6	14.8	5	93.8		1	86.0	
10	14	153.4 ± 5.2	28.9	22	124.1 ± 3.3	22.6	17	133.6 ± 4.6	27.9	5	105.6	
11	20	167.3 ± 5.3	35.4	33	145.9 ± 3.3	27.9	22	150.9 ± 4.6	32.2	8	136.1 ± 7.2	30.0
12	17	179.2 ± 4.4	26.8	41	173.6 ± 3.7	34.9	27	169.3 ± 4.2	32.3	13	157.2 ± 5.8	31.0
13	16	201.2 ± 4.7	28.1	44	192.2 ± 3.7	36.9	31	189.0 ± 3.6	30.1	16	174.4 ± 5.2	30.7
14	14	218.4 ± 4.9	26.9	39	210.5 ± 3.8	35.3	32	197.9 ± 4.0	33.9	18	194.7 ± 5.1	32.2
15	10	233.1 ± 5.5	25.8	33	226.3 ± 3.9	33.0	26	217.4 ± 4.7	35.5	18	204.3 ± 5.0	31.7
16	7	242.6 ± 6.8	26.8	19	239.4 ± 5.0	32.2	14	226.8 ± 6.9	38.1	17	216.2 ± 5.1	31.0
17	3	248.0		12	245.8 ± 6.5	33.4	6	228.0		11	220.5 ± 5.5	27.2

¹⁵ Approximately twenty per cent of the children used as subjects in the study are Jewish. In order to determine the influence of this heterogeneous racial group upon the correlation between the mental-test scores and precocious physiological maturing, Jewish subjects have been compared with non-Jewish in regard both to psychological scores at each age and the age of onset of puberty. The correlation noted in the present study is evidently not due to the presence of Jewish subjects. For the small number of Jewish boys and Jewish girls included, age of pubescence is not significantly different from that of the non-Jewish. The modal year of pubes for Jewish and non-Jewish boys is the same; the mean year is slightly earlier for the Jewish. The Jewish girls are slightly later than the non-Jewish by every measure of central tendency. Moreover, there is no consistent difference between the Jewish and non-Jewish subjects in the intelligence scores.

¹⁶ In this phase of the study, the first sign of pubescence (pubes) was selected for boys because the comparatively wide age range in its appearance--from the ninth birthday to the sixteenth. The range in the age of maturing of the girls is only slightly less--from the tenth birthday to the sixteenth.

¹⁷ This relationship probably does not exist after the attainment of physical maturity. Data given in Chapter VII show no correlation between the time of occurrence of pubescence and the mental status of adults.

TABLE XXII

AVERAGE SCORES ON PSYCHOLOGICAL TEST FROM AGE NINE THROUGH SEVENTEEN FOR BOYS OF THREE MATURITY GROUPS, WITH AXILLARY HAIR THE CRITERION

Age	Period of Pubescence					
	Before 14th birth-day		Between 14th and 15th birthdays		After 15th birthday	
	N	Mean	N	Mean	N	Mean
9 .	15	113.1	4	96.0	1	86.0
10 .	27	136.9	7	125.0	12	118.8
11 .	42	155.1	12	150.3	15	140.2
12 .	51	180.7	15	166.7	22	156.5
13 .	56	197.4	18	185.1	24	178.0
14 .	53	212.4	20	198.0	26	195.0
15 .	43	228.5	21	215.0	23	206.0
16 .	26	230.7	15	236.9	18	217.9
17 .	17	236.6	5	237.2	12	227.4

TABLE XXIII

DIFFERENCES BETWEEN THE MEAN PSYCHOLOGICAL-TEST SCORES FOR BOYS OF FOUR MATURITY GROUPS; BASED ON THE DATA OF TABLE XXI

Age	Group I- Group II		Group II- Group III		Group III- Group IV		Group I- Group IV	
	D	P.E. of D	D	P.E. of D	D	P.E. of D	D	P.E. of D
9 .	23.9	6.4	12.1		7.8		43.8	
10 .	29.3	6.2	-9.5	5.7	28.0		47.8	
11 .	21.4	6.2	-5.0	5.7	14.8	8.5	31.2	8.9
12 .	5.6	5.7	4.3	5.6	12.1	7.2	22.0	7.3
13 .	9.0	6.0	3.2	5.2	14.6	6.3	26.8	7.0
14 .	7.9	6.2	12.6	5.5	3.2	6.5	23.7	7.1
15 .	6.8	6.7	8.9	6.1	13.1	6.9	28.8	7.4
16 .	3.2	8.4	12.6	8.5	10.6	8.6	26.4	8.5
17 .	2.2		17.8		7.5		27.5	

Individual growth curves.- Individual growth curves in psychological test scores, standing height, weight, and ossification ratio have been drawn for 33 girls and 40 boys selected with regard to the completeness of records before and after puberty. Representative graphs are shown in Figures 16 and 17.

The individual growth curves agree with the data presented for different maturity groups in that they offer no consistent evidence of "pubertal spurt" in mental growth. There are variations in the apparent rate of mental development of some individuals, but these gains or losses seem to have no relationship to the period of pubescence. They are probably due to testing conditions, effort, and the like, since they occur at any age without reference to the time of onset of puberty. The psychological curves of Boy A and Boy C (Figure 16), and of Girl E and Girl F (Figure 17) are typical of fairly smooth individual curves of mental growth. The verticals which cut the curves indicate the time of appearance of signs of pubescence. There is no evidence of change in mental-growth rate because

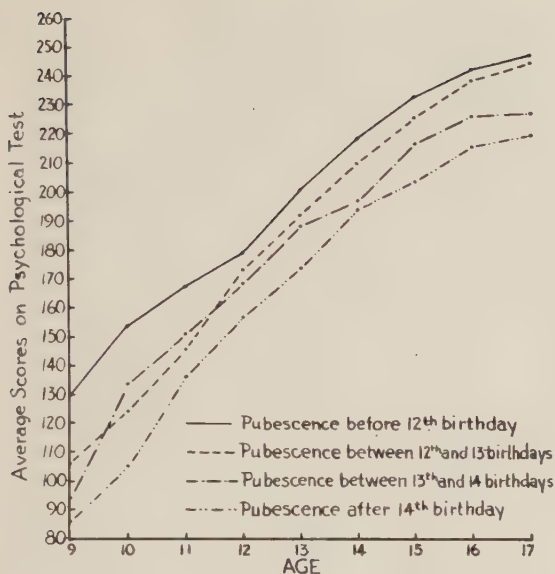


Figure 14.- Average scores on psychological test for boys of four maturity groups, with pubes the criterion of maturing. (Basis of graph, the means of Table XXI.)

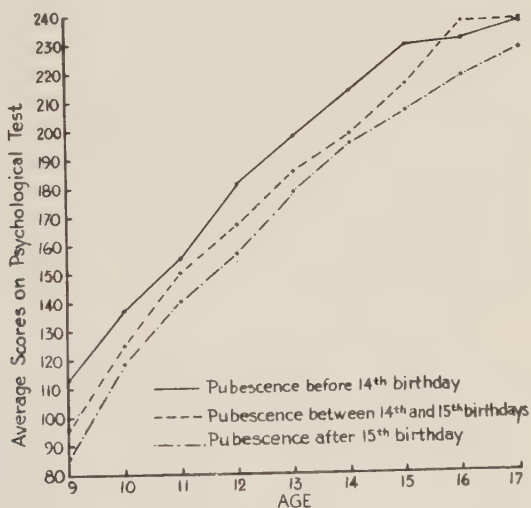


Figure 15.- Average scores on psychological test for boys of three maturity groups, with axillary hair the criterion of maturing. (Basis of graph, the means of Table XXII.)

TABLE XXIV

CORRELATION OF PRECOCITY OF PUBESCENCE WITH
PSYCHOLOGICAL SCORES AT VARIOUS AGES

Age when Psychological Test was Administered	Boys (Pubes)		Girls	
	N	r score psychological test and precocity of pubescence	N	r score psychological test and precocity of pubescence
10	58	.37 ± .08	61	.16 ± .08
11	83	.28 ± .07	85	.12 ± .07
12	98	.20 ± .07	95	.06 ± .07
13	106	.20 ± .06	92	.21 ± .07
14	103	.26 ± .06	90	.19 ± .07
15	87	.30 ± .07	78	.24 ± .07
16	57	.29 ± .08	54	.16 ± .09
17	31	.27 ± .11		

of the physiological event. Curves of height and weight, on the other hand, are in most instances positively accelerated during the year just prior to the year in which the first signs of puberty occur. Changes in carpal development, as measured by the ossification ratio, are most apparent in the data for boys than in those for girls.

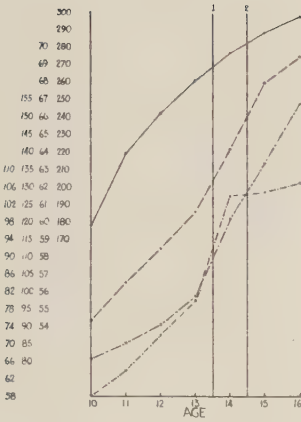
Summary of data for thirty-three girls.— Data for measures of height, weight, and intelligence of the 33 girls selected for study are summarized in the averages given in Tables XXV-XXVII. The 33 individuals have been classified with regard to age of physiological maturing. The data for the four groups distinguished on this basis have been treated according to a method used recently by Van Dyke.¹⁸ The birthdays at the beginning and end of the year during which the first sign of puberty occurs are the points from which yearly increments have been estimated. Table XXV gives, for each group, average values in each trait at periods of measurement before and after puberty. Table XXVI shows average yearly increments for each of the four maturity groups. The average yearly increments given in Table XXVII are the means of the individual increments of all cases in the four groups. These tables confirm the analysis of the individual curves. Acceleration in height and weight occurs during the year preceding the year of physiological maturation. There is no significant variation in growth rate in intelligence, as measured by the test, during this period.

Summary

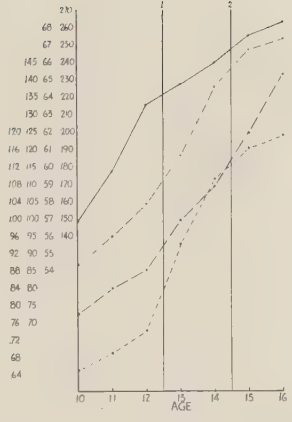
The results summarized in this chapter indicate that physiological maturing has positive correlation with mental development. This relationship is evident in the mental-growth curves of groups of boys and girls selected on the basis of age at onset of puberty. Moreover, coefficients of correlation between precocity of sexual maturing and psychological scores at various ages are positive at every age for which sufficient data are available, from age ten through seventeen. Analysis of individual and group mental-growth curves gives no evidence of positive acceleration during early adolescence. Growth rate in height and in weight is increased during the year preceding the year of onset of puberty, but the mental-growth rate,

¹⁸ G. E. Van Dyke, "The Effect of the Advent of Puberty on the Growth in Height and Weight of Girls," *The School Review*, XXXVIII (1930), 211-21.

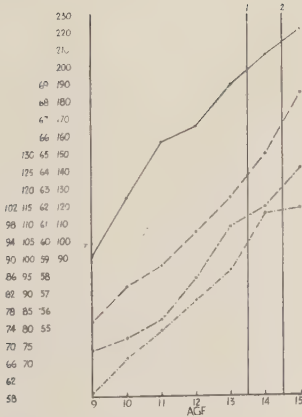
The results of this present study agree with those of Van Dyke for a larger number of subjects.



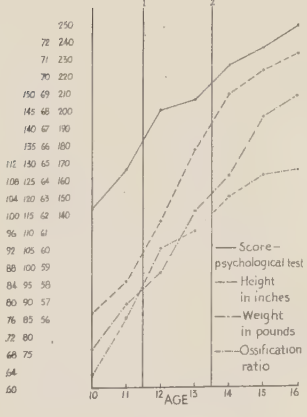
Boy A



Boy B

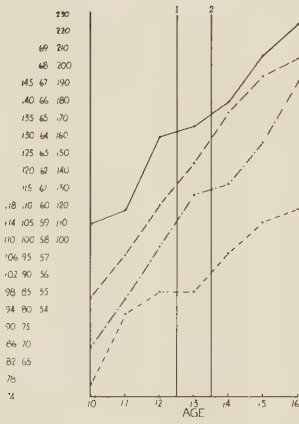


Boy C

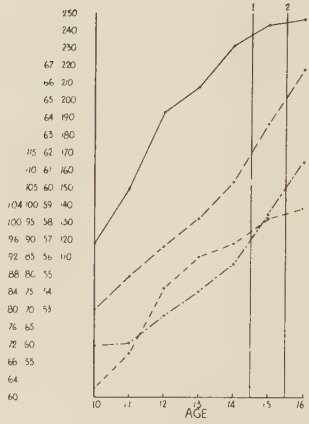


Boy D

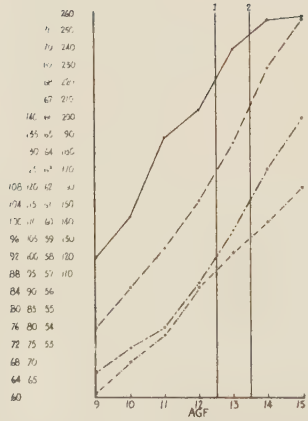
Figure 16.- Individual growth curves for twelve boys, each boy measured for six or seven consecutive birthdays. (The vertical lines which cut the growth curves indicate the ages at which the signs of physiological maturing occur. The first vertical indicates pubes; the second, axillary hair.)



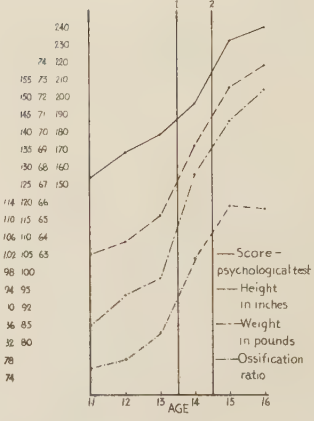
Boy E



Boy F

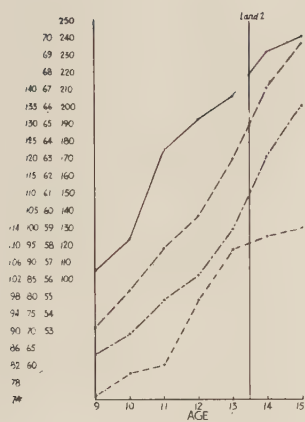


Boy G

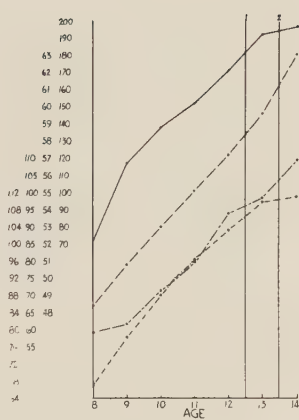


Boy H

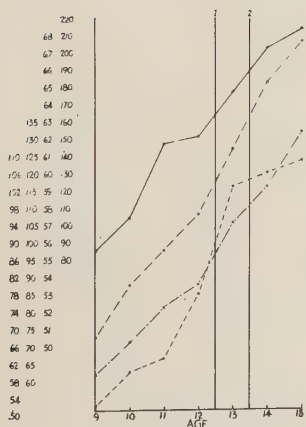
Figure 16.- Continued



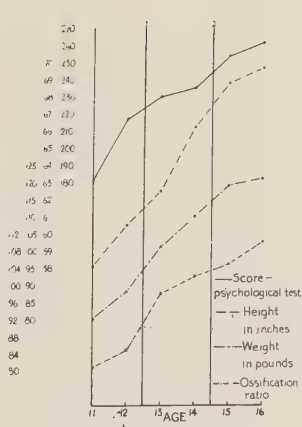
Boy I



Boy J

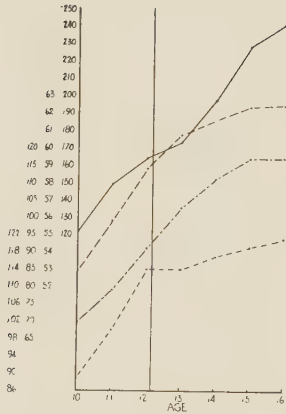


Boy K

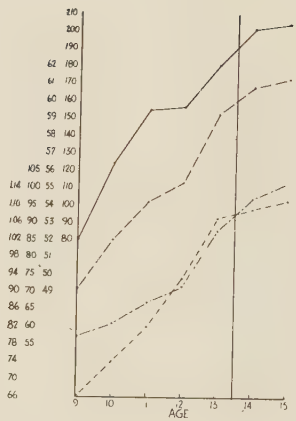


Boy L

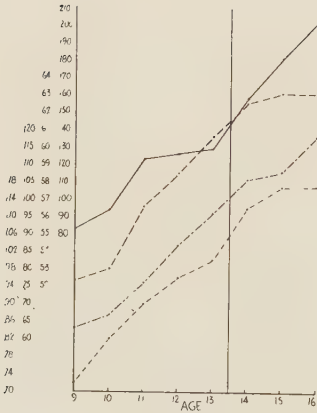
Figure 16.- Continued.



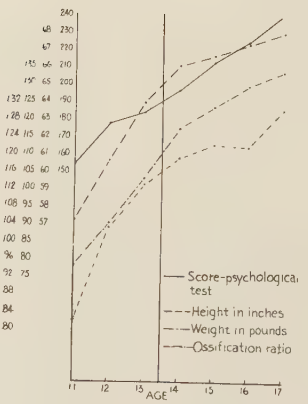
Girl A



Girl B

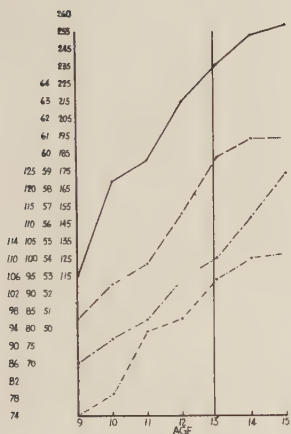


Girl C

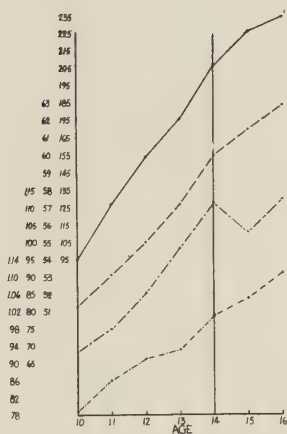


Girl D

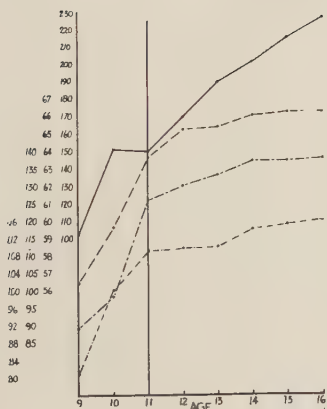
Figure 17.- Individual growth curves for twelve girls, each girl measured for six or more consecutive birthdays. (The vertical line which cuts the growth curves indicates the age, in years and months, of onset of pubescence.)



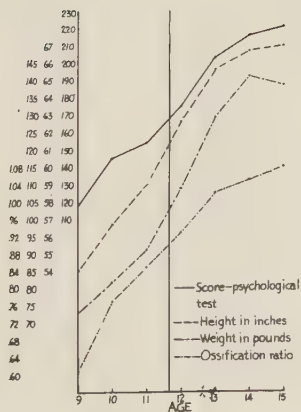
Girl E



Girl F

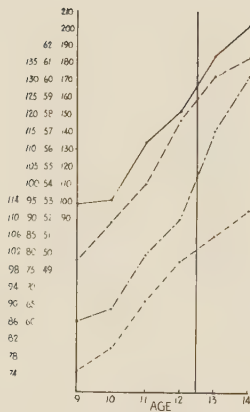


Girl G

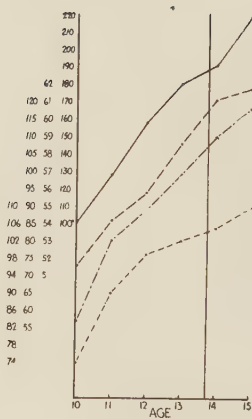


Girl H

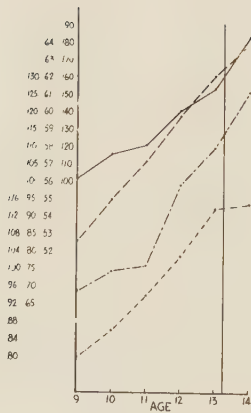
Figure 17.- Continued



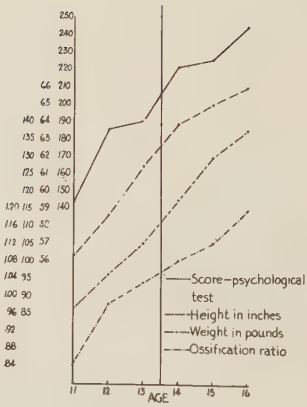
Girl I



Girl J



Girl K



Girl L

Figure 17.- Continued

TABLE XXV

AVERAGE MEASURES OF INTELLIGENCE, STANDING HEIGHT, AND WEIGHT AT PERIODS BEFORE AND AFTER PUBERTY; DATA FOR FOUR GROUPS OF GIRLS APPROXIMATELY HOMOGENEOUS IN AGE OF MATURING

Group	Function Measured	Mean of Measures				
		Two years before year of maturing	One Year before year of maturing	At beginning before year of maturing	At end of year of maturing	One year after year of maturing
Group I: Six girls maturing between the 10th and 12th birthdays	Intelligence test scores	91.00	111.66	124.33	147.83	178.50
	Height in inches	52.40	55.13	58.23	60.85	62.65
	Weight in pounds	69.57	77.50	90.63	103.62	117.87
Group II: Ten girls maturing between the 12th and 13th birthdays	Intelligence test scores	136.10	159.80	183.10	202.30	222.80
	Height in inches	54.75	57.23	60.40	62.91	63.90
	Weight in pounds	73.77	84.68	98.23	109.02	116.82
Group III: Nine girls maturing between the 13th and 14th birthdays	Intelligence test scores	144.44	159.11	177.11	195.44	208.88
	Height in inches	55.87	58.14	61.00	63.15	64.08
	Weight in pounds	75.90	84.89	96.87	108.27	115.20
Group IV: Eight girls maturing between the 14th and 15th birthdays	Intelligence test scores	154.00	181.37	197.37	207.37	232.00
	Height in inches	57.89	60.05	62.32	63.77	64.57
	Weight in pounds	85.31	96.04	104.18	111.28	118.81

TABLE XXVI

AVERAGE YEARLY INCREMENTS IN INTELLIGENCE-TEST SCORES, STANDING HEIGHT, AND WEIGHT; DATA FOR THE THIRTY-THREE GIRLS IN THE FOUR MATURITY GROUPS

Group	Function Measured	Mean Yearly Increments			
		Two years before year of maturing	One year before year of maturing	During year of maturing	One year after year of maturing
Group I: Six girls maturing between the 10th and 12th birthdays	Intelligence test scores	20.66	12.67	23.50	30.67
	Height in inches	2.73	3.10	2.62	1.80
	Weight in pounds	7.93	13.13	12.99	14.25
Group II: Ten girls maturing between the 12th and 13th birthdays	Intelligence test scores	23.70	23.30	19.20	20.50
	Height in inches	2.48	3.17	2.51	0.99
	Weight in pounds	10.91	13.55	10.79	7.80
Group III: Nine girls maturing between the 13th and 14th birthdays	Intelligence test scores	14.67	18.00	18.33	13.44
	Height in inches	2.27	2.86	2.15	0.93
	Weight in pounds	8.99	11.98	11.40	6.93
Group IV: Eight girls maturing between the 14th and 15th birthdays	Intelligence test scores	27.37	16.00	10.00	24.63
	Height in inches	2.16	2.27	1.45	0.80
	Weight in pounds	10.73	8.14	7.10	7.53

TABLE XXVII

AVERAGE YEARLY INCREMENTS IN INTELLIGENCE-TEST SCORES, STANDING HEIGHT, AND WEIGHT; SUMMARY OF DATA FOR THE THIRTY-THREE INDIVIDUALS IN THE FOUR MATURITY GROUPS

Function Measured	Mean Yearly Increments			
	Two years before year of maturing	One year before year of maturing	During year of maturing	One year after year of maturing
Intelligence-test scores	21.58	18.15	17.52	21.42
Height in inches .	2.39	2.85	2.18	1.07
Weight in pounds .	9.80	11.73	10.46	8.67

as measured by the test employed, is not similarly affected.

The findings with regard to the relation between the mental-growth curve and the occurrence of pubescence are in harmony with results previously presented. There is no evidence from the present study of changes in rate

of mental growth which may be explained as concomitants of physical events. Another point of agreement with other phases of the study may be noted through the comparison of Figures 13-15, the present chapter, with Figure 10, Chapter V. In every case, the mental and physical correlation persists throughout the period for which data are available; the brighter children remain taller; children earlier in age of pubescence are still, on the average, superior in intelligence-test scores. Again reference may be made to the study of adults (Chapter VII). The results of this investigation, and of a preceding extensive study, show no relation between the mental status of mature individuals and age of onset of puberty. If the mental-growth curves of the different maturity groups (Figures 13-15) could be extended a few years, they would probably coincide. The relationship between physiological maturing and mental development probably involves the entire period of growth from early childhood to adulthood. The nature of the correlation which evidently exists cannot, therefore, be apparent when only a section of the mental-growth curve is available.

CHAPTER VII

CORRELATIONS BETWEEN MENTAL AND PHYSICAL TRAITS OF ADULTS

The Problem

It has been noted in Chapter III that the coefficients of correlation between the mental-test scores and physical measurements of the Laboratory-School pupils tend to decrease during late adolescence. This fact suggested the desirability of making a cross-section correlation study at an age level above that made available by the Laboratory-School data. Accordingly, it was decided to determine for young men and young women of approximate mental and physical maturity, the relationship between mental-test scores and the physical characters most highly correlated with intelligence in the investigation of data for younger subjects.

Previous Studies of Adults

Most of the investigations of relationship between mental and physical traits have had children as subjects. The few studies of the problem which have been concerned with adults have resulted in the finding of zero or negligible correlation between mental and physical status. Pearson and others reported for more than one thousand Cambridge undergraduates a correlation of $-.01$ between intelligence and stature, and $.05$ between intelligence and weight. Scholastic standing was the criterion of intelligence.¹ Sargent found Harvard scholarship men shorter and lighter in weight than the average of 530 students of all sorts who entered the academic department between 1904 and 1906.² Naccarati and Lewy-Guinzbarg used the Thorndike Intelligence Examination as the measure of intelligence in a study of 252 college men under twenty-one years of age, and obtained the following correlations: intelligence and height, $-.11$; intelligence and weight, $-.02$.³ An investigation of 221 college students conducted by Naccarati, with the same criterion of intelligence, resulted in a correlation of $.04$ between intelligence and height, and $-.18$ between intelligence and weight.⁴ Sommerville studied the relation of many physical, motor, and sensory characteristics to various criteria of intelligence. The subjects were approximately one hundred Columbia undergraduates. The main objective of the study was to find an index of body build that would give a significant correlation with success. Measures of single traits and various indices of body build were correlated with the Thorndike Intelligence Examination and with measures of success in school. The coefficients reported are in all cases negligible.⁵ Brooks has presented data derived from mental and physical measurements of 1118 individuals of chronological ages from thirteen to twenty years. The subjects employed by him included groups of high-school students, 385 freshmen in Johns Hopkins University, and 446 women students in a normal school. The ages of both the university and the normal-school students ranged from sixteen to twenty. A battery of well-standardized intelligence tests was used. The physical traits correlated with intelligence were height, weight, chest girth, and physiological age.

¹ Cited by Sommerville (*infra*, footnote 5).

² D. A. Sargent, "The Physique of Scholars, Athletes, and the Average Student," *Popular Science Monthly*, 73 (1908), 248-56.

³ Sante Naccarati and R. L. Lewy-Guinzbarg, "Hormones and Intelligence," *Journal of Applied Psychology*, VI (1922), 221-34.

⁴ Sante Naccarati, *The Morphological Aspect of Intelligence*. Archives of Psychology, No. 45 (1921). Pp. 44.

⁵ R. C. Sommerville, *Physical, Motor and Sensory Traits*. Archives of Psychology, No. 75 (1924). Pp. 108.

When chronological age was controlled by age grouping, the correlation coefficients were found to tend to decrease in size from the youngest to the oldest chronological-age group. The correlations are not marked at any age. After age sixteen for girls, they are in most instances approximately zero.⁶

Present Data

The subjects.— The subjects selected for this phase of the present study were 140 young women between the nineteenth and twenty-fourth birthdays, and 140 young men between the twentieth and twenty-fifth. The modal age of the women was nineteen; the median age, twenty. The modal age of the men was twenty; the median age, twenty-one. All of the subjects were students in introductory courses in psychology and had had some acquaintance with intelligence tests. None was familiar with the test used in the present investigation. All of the young women were senior-college students. Most of the young men were in senior college; some were beginning graduate study. There was employed no student who, because of unusual environment or training, would have either special handicap or special advantage in a language test. All of the young women were students in a small Southern college which draws its students mainly from the foothills of Virginia and North Carolina. There is unusual racial homogeneity in the student-body of this college. Nearly all of the girls who served as subjects gave their national origin as Scotch or a mixture of Scotch and English. All are of Northern-European descent. In economic-social status, however, the group is very heterogeneous. There is also marked heterogeneity in mental ability, due to the fact that the only basis of selection of these students is graduation from an accredited high school. Of the 140 young men who served in the investigation, 100 were students in the University of Chicago; the remainder were drawn from a mid-western state university. In racial stock, the young men are approximately the same as the boys and girls in the Laboratory Schools. Of the University of Chicago men who were subjects in the present study, 21.0 per cent are Jewish, 75.0 per cent are of Northern-European stock, 4.0 per cent are of Southern-European. The 179 Laboratory-School boys who served as subjects are 20.1 per cent Jewish, 78.8 per cent Northern European, and 1.1 per cent partly Southern European. In economic-social status, the university men are more heterogeneous than the children of the Laboratory Schools.

The traits measured.— The physical measurements of adults were limited to standing height and weight, the two physical characters most consistently correlated with the mental-test scores in the study of the Laboratory-School children. A record of physiological age was secured in the case of the young women. In obtaining the data concerning age of physiological maturing, each girl was questioned, and her memory of the event was verified by an independent statement from her mother. Five per cent of the records of pubescence were rejected because of lack of agreement between mother and daughter. The mental test used in the study of children was employed with adults, but with one change in the method of administering it—the parts of the test which were administered orally to the children (the Terman vocabulary and opposites) were arranged as a written test for adults. The adults were tested, in nearly all instances, in small groups of two or three.

The results.— The results of the study of adults appear in Tables XXVIII-XXX.

The data given in Table XXVIII show no significant relation between the mental-test scores and the physical measures. This absence of correlation is not due to lack of variability in the mental and physical measures, as

⁶ Fowler D. Brooks, "The Organization of Mental and Physical Traits during Adolescence," Journal of Applied Psychology, XII (1928), 228-41.

TABLE XXVIII

COEFFICIENTS OF CORRELATION BETWEEN SCORES ON PSYCHOLOGICAL TEST AND MEASURES OF STANDING HEIGHT AND WEIGHT; DATA FOR UNIVERSITY MEN AND COLLEGE WOMEN

Group	Height and mental test		Weight and mental test	
	N	r	N	r
University men (all cases)	140	$-.01 \pm .06$	140	$-.09 \pm .06$
College women (all cases)	140	$-.00 \pm .06$	140	$-.09 \pm .06$
All men within 2 S.D. of mean . . .	131	$-.05 \pm .06$	134	$-.11 \pm .06$
All women within 2 S.D. of mean . .	136	$-.04 \pm .06$	134	$-.04 \pm .06$
University of Chicago men	100	$.01 \pm .07$	100	$-.08 \pm .07$
State University men	40	$-.08 \pm .11$	40	$-.18 \pm .10$

TABLE XXIX

MEANS AND STANDARD DEVIATIONS OF MEASURES OF INTELLIGENCE, STANDING HEIGHT, AND WEIGHT; DATA FOR UNIVERSITY MEN AND COLLEGE WOMEN

Group	Scores mental test		Height in inches		Weight in pounds	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
University men (all cases)	264.6 ± 1.5	26.7	$69.3 \pm .1$	2.5	151.6 ± 1.1	19.1
College women (all cases)	242.2 ± 2.3	39.7	$64.0 \pm .1$	2.3	$118.2 \pm .8$	13.6
University of Chicago men	266.5 ± 1.8	27.3	$69.3 \pm .2$	2.5	153.7 ± 1.3	18.9
State University men	260.0 ± 2.6	24.3	$69.2 \pm .3$	2.5	146.3 ± 2.0	18.7

TABLE XXX

MEANS AND STANDARD DEVIATIONS OF PSYCHOLOGICAL SCORES FOR DIFFERENT MATURITY GROUPS OF COLLEGE WOMEN

Group	N	Mean	S.D.
Before 13th birthday	28	236.3 ± 2.2	37.2
Between 13th and 14th birthdays	60	238.0 ± 2.7	44.1
After 14th birthday	37	242.6 ± 1.9	31.8

Table XXIX shows. The standard deviation of 39.7 in the mental-test scores of college women is greater than the standard deviation in the scores of the Laboratory-School children at any age (Table VII, Chapter III). The university men, a more highly selected group than the college women, also have considerable variability in intelligence. Senior-college students are, to be sure, a highly selected group, but the children in the Laboratory Schools are also highly selected; and it evidently not because of differences in variability that the adult students and the children differ in the correlation between the mental and physical characteristics selected. Another fact of importance is that correlation between mental and physical traits has been found for a socially homogeneous group during the period of development, while no significant relationship between mental and

physical status is apparent for socially heterogeneous groups which are at least approximately mature both physically and mentally. It should also be noted from Table XXX, that for young women there are no marked differences in the average mental-test scores of groups varying in age of advent of puberty.⁷ For these subjects, the correlation between precocity of pubescence and scores on the intelligence test is $-.01 \pm .06$.

Summary

The present study is in agreement with previous investigations in the finding of zero or negligible coefficients of correlation between the mental-test scores of adults and measures of height and weight (the physical traits most consistently correlated with intelligence in this and in earlier studies when children are employed as subjects). It is also indicated, as in a previous study, that the age of onset of puberty is unrelated to the intellectual status of young women.

The objection frequently made to comparison of results for children with those for adults in studies of this type is that the adult subjects have been drawn from colleges and universities, and are, therefore, more highly selected than the younger ones. This criticism does not apply in the present case, since the younger subjects are, in nearly all cases, superior in intelligence to the general average. It is significant, also, that the Laboratory-School pupils are more homogeneous in economic-social status than are the older subjects--a fact which tends to refute the rather common theory that the basis of correlation between mental and physical traits is in economic and cultural differences.

The present phase of the study is significant in the interpretation of the results for younger subjects. If the relationships demonstrated for a developing group do not appear at maturity, the correlation is seemingly one of relative maturity, i.e., rate of development, rather than one of permanent level. The present investigation suggests that this is the case.

⁷ Reference was made in Chapter V to similar results from a study reported by Viteles. (Morris S. Viteles, "The Influence of Age of Pubescence upon the Physical and Mental Status of Normal School Students," Journal of Educational Psychology, XX (1929), 360-68.)

CHAPTER VIII

SUMMARY AND CONCLUSIONS

The investigation reported in the foregoing pages is concerned with analysis of the relationships between mental and physical growth. Previous studies have indicated that there is low positive correlation between the mental and physical status of children. The results of these studies have failed, however, to give information concerning the nature of the association demonstrated. The absence of correlation between the mental and physical ratings of mature individuals--a finding reported from most investigations which have employed adults as subjects--has suggested to some psychologists that the relationship found during childhood is one of relative maturity, i.e., a correlation in rate of mental and physical development. The present study utilizes data which have been collected during a period of eleven years through the repeated testing and measuring of a large number of children. Such data offer unusual possibilities for determining the type of association involved in the correlation between mental and physical traits. A supplementary phase of the study deals with the relationship between the mental and physical measures of young men and young women. The data for adults are especially significant for comparison with those for younger subjects in that the same mental test was used; moreover, the young men employed are practically the same as the younger subjects of the same sex in racial stock and in cultural background.

The problems which have received the principal emphasis in the study are: (1) Is the relation of mental to physical growth one of level (permanent status) or of rate of development? (2) If the correlation is in rate of growth, is the entire period of development involved, or is correlation found only in a relation between fluctuations in rate of mental and physical growth?

The statement of results which follows is based upon evidence presented in Chapters III-VII.

Results for Laboratory-School Subjects

1. There is agreement with the trend of previous investigations in the finding of low positive correlation between the mental and physical status of children. Results of the present study offer rather convincing evidence of some degree of positive relationship between the measure of intelligence employed and each of the selected indices of physical growth--namely, standing height, sitting height, weight, ossification ratio, normal chest girth, and lung capacity.¹ Coefficients of correlation are given for the sexes separately at each age from eight through seventeen. For both boys and girls, standing height has the closest relation to intelligence, with a median coefficient of .30 in the case of boys; sitting height and weight are next in correlation; measures of chest girth for boys, and of ossification ratio for both sexes, correlate less consistently than do the other physical traits with the mental-test scores. The coefficients for boys tend to be slightly higher than those for girls, considering the data in general.²

The results from the correlation of birthday measurements are significant because of the precise control of the factor of chronological age. The experimental control of age is probably more valid as a method of eliminating this factor than is the partial correlation technique or any other

¹ Measures of lung capacity are given for boys only.

² The application of tests of linearity to tables with comparatively large populations shows that the correlation which exists is, in the main, linear.

method of correcting for age.

2. There is a general trend of decrease in coefficients of correlation between mental and physical measures after age fourteen or fifteen. This trend is more marked in the data for girls than in those for boys, especially when groups of the same children are followed for three or more consecutive birthdays during late adolescence. Probably the earlier physical maturity of girls is responsible for this difference between the sexes. The decrease in the coefficients about ages sixteen and seventeen suggests that the relationship between the intelligence scores and each of the physical traits would be negligible at maturity.

3. The intercorrelation of the selected variables in amount of absolute gain from birthday to birthday shows that increments in the mental-test scores have no consistent relation to increments in any of the physical traits; the absolute gains in the physical measures are, on the other hand, closely interrelated in most cases. It is difficult to interpret this finding in relation to the general problem of the nature of the correlation between mental and physical growth. One is not justified in concluding from this phase of the study that there is no correlation between rate of mental and physical development. The degree of mental and physical relationship found from the correlation of birthday scores is low; and the unit of measurement for the increment is too small, perhaps, to indicate a relationship in growth rate if the correlation between mental and physical growth involves a period of time much longer than the interval of one year. The results from the intercorrelation of yearly increments do suggest however, that minor fluctuations in rate of physical growth are unrelated to changes in rate of mental development. It has been noted that some writers have reported concomitance in mental and physical "spurts."³ The present data do not support such conclusions.

4. Comparison of curves of mental and physical growth strengthens the inference that changes in rate of mental and physical development are unrelated. Analysis of growth curves for individuals and for groups reveals significant differences between mental and physical trends of development during the period studied, from age eight through seventeen. Positive acceleration in rate of physical growth is not accompanied by a corresponding change in rate of mental growth, nor do the points of decline in rate of mental and physical maturing appear to be related. The mental-growth curve continues with only slight negative flexion after physical maturity has been approximately reached.

It was intended at the beginning of the investigation to combine the various indices of physical growth in such a way that a single curve of physical development might be presented for comparison with the curve of intelligence. As the study developed, this plan was abandoned for the following reasons: (1) Differences between trends in mental and physical development are too pronounced for such technique to be necessary; for example, the data for boys show that during the period of early adolescence, growth rate is positively accelerated to a marked degree in every physical trait selected, while the mental-growth curve is slightly negative in flexion.⁴ Curves of growth in the several physical traits differ to some extent, but a general pattern during early adolescence may be detected without combining the curves. (2) The combined physical curve seems to be inadvisable statistically because of the practically negative results from the correlation of mental-test increments with increments in each of the physical traits. Such data are not suitable for multiple correlation.

5. Sex differences in rate of physical maturing are marked for the subjects employed, but the boys and girls have a very similar type of mental

³ Chapter VI, footnotes 11 and 12.

⁴ Chapter IV, Figure 2.

development. There is no consistent evidence that the earlier physical maturing of the girls is associated with more rapid mental development. There is, in most instances, striking similarity between the curves of intelligence for the two sexes.

6. Consideration of trends in mental and physical variability in succeeding ages suggests, as do other phases of the present study, that marked changes in rate of physical growth are not related to changes in rate of mental growth; moreover, differences in the rate of mental maturing are apparently not correlated with differences in rate of physical maturing within the limits of the period studied for the Laboratory-School subjects. Measures of absolute variability, and of variability in terms of the coefficient of variation, are given for boys and girls separately at each age from the eighth birthday through the seventeenth. The curves of variability in each of the physical traits are clearly indicative of changes in growth rate, since they are in close agreement with growth curves based upon absolute physical measures. Sex differences in growth rate are apparent in these curves of physical variability. Curves of variability based upon the mental-test scores differ markedly from the trends observed in the physical data. There is no clear evidence of sex differences in rate of mental growth. Girls are more homogeneous than boys in the mental-test scores at any given age; there is no crossing of the curves of mental variability for the sexes, as there is in curves based upon the various physical measures.

Significant differences between trends in mental and physical variability appear when a group of subjects, 42 boys measured each year from the tenth birthday through the sixteenth, is divided into three sections on the basis of rank in mental-test scores. Both the mental-growth curves and the curves of variability for these sub-groups are indicative of group differences in rate of mental maturing; individuals of higher level in ability tend to a somewhat more rapid rate of development. Similar analysis of measures of standing height for the three groups gives no evidence of corresponding differences in rate of growth in height within the period studied, although there is positive relationship at each age between the measures of height and the mental-test scores. It is important that these results should be interpreted with reference to data from other phases of the study; otherwise, one may conclude that there is a permanent relation between height and intelligence, and no correlation in rate of growth. Data for adults, and for subjects sixteen and seventeen years of age, do not justify this inference. There has been found little decrease in correlation between the mental and physical status of boys before age seventeen, which is beyond the period considered for the groups in question. The trend of correlation coefficients for the study as a whole, suggests that the differences in height between the three ability groups of boys would be negligible at maturity if the curves could be extended.

7. Analysis of mental-growth curves for individuals, and for groups of boys and girls approximately homogeneous in age of physiological maturing, fails to give indication of positive acceleration in mental-growth rate during early adolescence. This finding is in harmony with certain results of the study previously summarized; the present data offer no support for the theory that changes in rate of mental development may be explained as concomitants of abrupt physical events. It is especially significant that the groups for which the mental-growth curves are presented in this study have been selected on the basis of age at onset of puberty. If acceleration does occur about the time of puberty, it would probably be apparent in these curves for groups which have so small a range in individual differences in age of maturing. The data for these groups show that growth rate in height and in weight is increased during the year preceding the year of onset of puberty; but the mental-growth rate, as measured by the test employed, is not similarly affected.

8. Physiological maturing is found to have positive correlation with the mental-test scores at every age for which sufficient data are available for analysis--from age nine through seventeen, for boys; and from nine through sixteen, for girls. This relationship is consistently marked in the mental-growth curves of groups of boys and girls selected on the basis of age at onset of puberty. Moreover, coefficients of correlation between precocity of pubescence and psychological scores at various ages are positive at every age for which the data warrant computation--from age ten through seventeen, for boys; and from ten through sixteen, for girls. The average of the coefficients is approximately the same as for standing height with the mental-test scores. There is decrease in the correlation between physiological maturing and intelligence after age fifteen, but the loss is too slight, and the trend of the coefficients too irregular, for statistical significance.

Results for Adults

1. The present study agrees with previous investigations in the finding of zero or negligible coefficients of correlation between the mental-test scores of adults and measures of standing height and weight. Height and weight were selected for this phase of the investigation because of the relatively consistent correlation of these physical traits with the mental-test scores in the study of younger subjects. Inspection of the data shows that lack of correlation between the mental and physical criteria is not due to a comparatively low degree of variability in the mental-test scores of the more mature subjects. The young women employed were, indeed, evidently less highly selected than the Laboratory-School subjects, and less homogeneous in intelligence. The boys used in the study were matched with a group of young men fairly similar in type; but the young women who served as subjects were decidedly more heterogeneous than the girls, both in economic-social status and in mental ability. These facts concerning the subjects of the study are significant in that they indicate the influence of maturity upon the correlation between mental and physical status. Factors which have been cited in explanation of mental and physical relationship are apparently insignificant when the subjects are approximately mature individuals.

2. The age of onset of puberty has no relation to the mental-test ratings of young women. This finding of the present study is in harmony with the other data for adults, and agrees with the results reported by other investigators.

Conclusions

The hypothesis suggested by the results of the present study is that the mental and physical relationship noted in the data for immature subjects is a correlation in rate of growth rather than in permanent level. This inference has the following factual basis: (1) the general finding, from the present study and previous investigations, of low positive correlation between intelligence and common physical measures in a developing group; (2) decrease in the coefficients of correlation during late adolescence, a trend noted in the present study; (3) the agreement of present data with those of other investigations in the finding of practically zero relationship between the mental-test scores of adults and the physical traits most consistently correlated in the studies of children; (4) the positive correlation of precocity of pubescence with the mental-test scores at every age considered for the developing group, a relation existing years before the earliest signs of puberty; and (5) the absence in the data for adults of any relationship between intelligence ratings and age of occurrence of pubescence.

The conclusion that the relationship between mental and physical status is one of relative maturity can be accepted only tentatively because of

limitations in the data for the period of late adolescence. The data for the Laboratory-School subjects end with the seventeenth birthday, at which age there is still, for certain phases of the study, correlation between the mental and physical measures. The gap between this age and that of the college students must be bridged by inference. Conclusive evidence concerning the problem can come only through the repeated testing and measuring of a large number of the same subjects throughout the period of late adolescence until maturity is completely attained. It may be said, however, that the data of the present study, combined with those of other investigations, support the hypothesis presented with a fairly high degree of consistency.

The results of the investigation are entirely consistent in their indication that there is no relationship between periods of acceleration in rate of mental and physical growth. Negative evidence relative to this problem has been noted in the following phases of the study: (1) the correlation of increments, (2) comparison of curves of mental and physical growth, (3) analysis of trends in variability, and (4) study of the mental-growth curve with reference to the time of onset of puberty. There apparently are no abrupt physical events which are associated with corresponding changes in mental status. Study of the relation of age of pubescence to mental growth suggests that individual differences in rate of physical maturing exist from earliest childhood, and are associated with differences in rate of mental maturing. It seems probable that the entire period of development is involved in the correlation between mental and physical growth.

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APPENDIX

TABLE I

DISTRIBUTION OF CASES USED IN THE STUDY ACCORDING TO THE NUMBER OF CONSECUTIVE BIRTHDAY EXAMINATIONS IN THE MENTAL AND PHYSICAL TRAITS*

Beginning at Age	Data for Boys								Data for Girls							
	Number of Consecutive Birthday Examinations								Number of Consecutive Birthday Examinations							
	2	3	4	5	6	7	8	Total	2	3	4	5	6	7	8	Total
8	2	9	10	8	2	2		33	3	8	6	15				32
9	1	2	6	7	2	6	1	25	4	7	5	8	4	1	4	33
10	3	2	6	10	6	8		35	8	8	2	2	5	4	1	30
11	5	4	4	9	6	3		31	6	6	8	6	4	3	1	34
12		2	3	6	6	2		19	5		8	4	2	2		21
13	1	4	6	6	3			20	5	2	3	6				16
14	4	4	6	2				16	4	3	5	2				14
15		2	1					3	3	2	1					6
16									1							1
Total . . .	16	29	42	48	25	21	1	182**	39	36	38	43	15	10	6	187**

*This description of data applies to the main body of the thesis. Additional measurements were made to secure the five- and seven-year group curves presented in Chapters IV and V. Data for the five-year runs are given in the following tables of the Appendix.

**The subjects of the study included 179 boys and 178 girls. Three of the boys and nine of the girls have gaps in the period of repeated measurement.

TABLE 17

MEANS AND STANDARD DEVIATIONS IN EACH TRAIT FOR SIX GROUPS OF GIRLS,
EACH GROUP MEASURED FOR FIVE CONSECUTIVE BIRTHDAYS

Group I: Fifteen Girls Measured from the 8th through the 12th Birthdays										
Function Measured	Means and Standard Deviations at Each Age									
	8		9		10		11		12	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Psychological	88.1 ± 2.9	16.9	98.9 ± 3.4	19.6	122.5 ± 3.8	21.7	153.2 ± 5.2	29.7	179.4 ± 5.9	33.7
Standing height	51.2 ± 0.3	1.8	53.6 ± 0.4	2.1	56.1 ± 0.4	2.4	58.7 ± 0.5	2.7	61.2 ± 0.5	2.9
Sitting height	27.3 ± 0.2	1.0	28.5 ± 0.2	1.0	29.8 ± 0.2	1.2	30.9 ± 0.2	1.3	31.7 ± 0.2	1.3
Weight	61.5 ± 1.1	6.2	70.6 ± 1.7	9.5	79.7 ± 2.1	11.8	90.0 ± 2.3	13.1	102.4 ± 2.8	15.9
Ossification ratio	.654 ± .017	.100	.763 ± .019	.111	.861 ± .019	.109	.973 ± .017	.098	1.075 ± .016	.092
Chest girth	24.8 ± 0.2	1.1	25.6 ± 0.3	1.5	27.1 ± 0.3	1.7	28.2 ± 0.4	2.1	28.8 ± 0.4	2.4
Group II: Seventeen Girls Measured from the 9th through the 13th Birthdays										
Function Measured	Means and Standard Deviations at Each Age									
	9		10		11		12		13	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Psychological	105.8 ± 3.0	18.4	131.0 ± 4.3	26.0	151.5 ± 4.3	26.0	172.9 ± 5.2	31.5	195.2 ± 5.3	32.4
Standing height	51.7 ± 0.4	2.4	53.9 ± 0.4	2.6	56.4 ± 0.5	2.9	59.0 ± 0.5	2.9	61.4 ± 0.4	2.4
Sitting height	27.5 ± 0.2	1.2	28.4 ± 0.2	1.2	29.6 ± 0.2	1.5	30.9 ± 0.2	1.5	32.2 ± 0.2	1.3
Weight	65.1 ± 1.5	9.4	73.9 ± 1.7	10.2	82.6 ± 1.6	9.8	93.3 ± 2.3	14.2	103.3 ± 1.9	11.9
Ossification ratio	.754 ± .010	.062	.855 ± .010	.064	.964 ± .011	.073	1.024 ± .009	.055	1.078 ± .007	.044
Chest girth	24.3 ± 0.2	1.3	25.8 ± 0.2	1.3	27.3 ± 0.3	1.7	28.5 ± 0.3	1.6	29.3 ± 0.3	1.6
Group III: Twenty-one Girls Measured from the 10th through the 14th Birthdays										
Function	10		11		12		13		14	
Psychological	126.5 ± 4.2	28.5	153.1 ± 4.0	27.5	171.2 ± 4.6	31.4	191.7 ± 4.7	32.1	212.3 ± 4.3	29.3
Standing height	54.1 ± 0.3	2.2	56.7 ± 0.4	2.6	59.4 ± 0.4	2.9	61.8 ± 0.4	2.5	63.3 ± 0.3	2.2
Sitting height	28.3 ± 0.2	1.3	29.5 ± 0.2	1.3	30.9 ± 0.3	1.8	32.2 ± 0.2	1.5	33.1 ± 0.2	1.3
Weight	75.4 ± 1.6	11.1	84.6 ± 2.1	14.1	96.7 ± 2.3	15.4	106.0 ± 2.0	13.8	115.1 ± 2.0	13.3
Ossification ratio	.849 ± .014	.094	.941 ± .010	.070	1.013 ± .010	.065	1.070 ± .008	.055	1.108 ± .006	.039
Chest girth	26.3 ± 0.3	1.7	27.5 ± 0.3	1.9	29.2 ± 0.3	2.1	30.1 ± 0.3	1.8	31.0 ± 0.2	1.5
Group IV: Twenty-nine Girls Measured from the 11th through the 15th Birthdays										
Function	11		12		13		14		15	
Psychological	148.7 ± 3.3	26.5	169.2 ± 3.6	28.5	191.2 ± 3.3	26.1	210.4 ± 3.3	26.1	221.2 ± 2.8	22.5
Standing height	56.7 ± 0.3	2.5	59.2 ± 0.4	2.8	61.6 ± 0.3	2.6	63.3 ± 0.3	2.4	64.0 ± 0.3	2.4
Sitting height	29.4 ± 0.2	1.4	30.6 ± 0.2	1.7	32.0 ± 0.2	1.6	33.0 ± 0.2	1.5	33.5 ± 0.2	1.4
Weight	82.4 ± 1.9	14.8	93.2 ± 2.1	16.5	103.5 ± 2.1	17.0	112.8 ± 2.1	17.1	118.5 ± 1.9	15.5
Ossification ratio	.916 ± .010	.080	1.008 ± .008	.064	1.063 ± .008	.064	1.105 ± .006	.048	1.142 ± .007	.052
Chest girth	27.2 ± 0.3	2.0	28.6 ± 0.4	2.9	30.1 ± 0.3	2.2	30.9 ± 0.3	2.1	31.2 ± 0.2	1.9
Group V: Twenty-six Girls Measured from the 12th through the 16th Birthdays										
Function	12		13		14		15		16	
Psychological	163.9 ± 4.0	29.9	190.7 ± 3.8	28.5	207.6 ± 4.0	29.9	221.2 ± 3.5	26.7	232.7 ± 3.2	24.1
Standing height	59.4 ± 0.4	2.7	61.6 ± 0.3	2.4	63.2 ± 0.3	2.2	64.0 ± 0.3	2.2	64.6 ± 0.3	2.2
Sitting height	30.7 ± 0.2	1.5	32.0 ± 0.2	1.4	33.0 ± 0.3	2.2	33.7 ± 0.2	1.3	34.0 ± 0.2	1.4
Weight	93.7 ± 2.1	16.0	104.2 ± 2.0	15.4	112.2 ± 1.5	11.5	118.3 ± 1.8	13.7	121.5 ± 1.7	12.8
Ossification ratio	.991 ± .010	.074	1.047 ± .008	.062	1.096 ± .007	.050	1.128 ± .007	.050	1.144 ± .007	.051
Chest girth	28.3 ± 0.3	2.3	30.0 ± 0.3	2.1	30.6 ± 0.3	1.9	31.3 ± 0.2	1.8	31.3 ± 0.2	1.7
Group VI: Thirty-four Girls Measured from the 13th through the 17th Birthdays										
Function	13		14		15		16		17	
Psychological	185.9 ± 2.8	23.9	203.2 ± 2.5	21.3	213.6 ± 2.4	20.5	234.3 ± 2.6	22.7	248.5 ± 2.8	24.6
Standing height	61.4 ± 0.3	2.2	62.9 ± 0.2	2.1	63.7 ± 0.2	2.0	64.2 ± 0.2	2.0	64.3 ± 0.2	2.1
Sitting height	32.0 ± 0.2	1.4	32.9 ± 0.1	1.2	33.4 ± 0.1	1.2	33.7 ± 0.1	1.1	33.9 ± 0.1	1.1
Weight	102.6 ± 2.0	16.9	111.0 ± 1.9	16.0	115.7 ± 1.7	14.5	120.4 ± 1.5	12.6	121.7 ± 1.6	13.6
Ossification r.	1.047 ± .007	.063	1.093 ± .006	.051	1.124 ± .006	.050	1.144 ± .006	.056	1.171 ± .007	.059
Chest girth	29.5 ± 0.2	2.0	30.5 ± 0.2	2.0	30.8 ± 0.2	2.1	30.7 ± 0.2	2.1	30.8 ± 0.2	2.0

MEANS AND STANDARD DEVIATIONS IN EACH TRAIT FOR SIX GROUPS OF BOYS,
EACH GROUP MEASURED FOR FIVE SUCCESSIVE BIRTHDAYS

Group I: Twelve Boys Measured from the 8th through the 12th Birthdays										
Function Measured	Means and Standard Deviations at Each Age									
	8		9		10		11		12	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Psychological .	89.8 ± 3.3	16.7	105.5 ± 3.8	19.7	123.9 ± 4.2	21.7	146.3 ± 4.1	21.0	177.8 ± 5.8	29.8
Standing height	51.3 ± 0.3	1.7	53.6 ± 0.4	1.8	55.8 ± 0.4	1.8	58.0 ± 0.4	1.9	60.0 ± 0.4	2.0
Sitting height	27.5 ± 0.1	.6	28.4 ± 0.1	.7	29.6 ± 0.2	.8	30.1 ± 0.1	.7	30.8 ± 0.1	.7
Weight	60.8 ± 1.1	5.7	68.2 ± 1.8	9.1	75.9 ± 1.3	6.9	85.5 ± 1.7	8.9	92.7 ± 1.7	8.6
Ossification ratio	.537 ± .017	.086	.613 ± .018	.091	.700 ± .014	.074	.785 ± .016	.081	.881 ± .017	.085
Chest girth . .	24.2 ± 0.1	.7	25.3 ± 0.1	.7	26.3 ± 0.2	1.0	27.3 ± 0.2	1.1	28.1 ± 0.2	1.2
Lung capacity .	102.2 ± 2.9	14.9	116.1 ± 2.7	13.7	126.1 ± 3.0	15.6	138.7 ± 4.2	21.7	154.8 ± 5.6	29.0
Group II: Twenty Boys Measured from the 9th through the 13th Birthdays										
Function	9		10		11		12		13	
Psychological .	108.3 ± 3.6	24.2	128.9 ± 4.2	28.1	151.7 ± 4.9	32.8	177.2 ± 5.1	33.9	199.6 ± 5.2	34.8
Standing height	53.0 ± 0.4	2.6	55.1 ± 0.4	2.7	57.2 ± 0.4	2.7	59.1 ± 0.4	2.8	61.8 ± 0.4	2.9
Sitting height	28.0 ± 0.3	1.8	29.0 ± 0.2	1.3	29.8 ± 0.2	1.2	30.6 ± 0.2	1.1	31.7 ± 0.2	1.2
Weight	69.8 ± 1.8	12.0	75.9 ± 1.8	11.7	84.8 ± 1.9	12.4	94.5 ± 2.1	14.1	104.6 ± 2.1	13.9
Ossification r.	.638 ± .012	.078	.715 ± .011	.076	.812 ± .013	.088	.906 ± .014	.090	1.000 ± .013	.087
Chest girth . .	25.3 ± 0.3	1.9	26.1 ± 0.3	1.9	27.0 ± 0.3	1.7	28.2 ± 0.3	2.1	29.1 ± 0.3	2.0
Lung capacity .	105.5 ± 2.7	18.1	131.0 ± 2.9	19.5	134.5 ± 3.0	20.2	150.2 ± 3.2	21.1	170.3 ± 3.1	20.6
Group III: Thirty-five Boys Measured from the 10th through the 14th Birthdays										
Function	10		11		12		13		14	
Psychological .	128.8 ± 2.8	24.7	147.7 ± 3.6	31.4	172.1 ± 3.9	34.1	192.6 ± 3.6	31.6	208.3 ± 3.7	32.1
Standing height	54.5 ± 0.2	2.0	56.5 ± 0.2	2.0	58.6 ± 0.3	2.5	61.2 ± 0.3	2.8	64.3 ± 0.3	3.0
Sitting height	28.5 ± 0.1	1.0	29.4 ± 0.1	1.0	30.3 ± 0.1	1.2	31.5 ± 0.1	1.3	32.9 ± 0.2	1.6
Weight	70.1 ± 1.0	8.8	77.6 ± 1.0	8.9	86.2 ± 1.4	12.7	97.2 ± 1.8	15.5	109.0 ± 1.9	16.6
Ossification r.	.659 ± .011	.099	.747 ± .012	.101	.858 ± .012	.105	.958 ± .010	.085	1.049 ± .007	.061
Chest girth . .	25.6 ± 0.2	1.5	26.1 ± 0.1	1.3	27.2 ± 0.2	1.5	28.1 ± 0.2	1.7	29.8 ± 0.2	2.0
Lung capacity .	124.0 ± 2.6	22.6	131.0 ± 2.7	23.3	144.7 ± 2.6	23.1	164.9 ± 3.6	31.5	191.3 ± 4.7	41.4
Group IV: Thirty-nine Boys Measured from the 11th through the 15th Birthdays										
Function	11		12		13		14		15	
Psychological .	152.0 ± 3.7	34.1	175.9 ± 3.7	34.4	194.3 ± 3.5	32.4	212.5 ± 3.6	33.7	226.9 ± 3.1	28.6
Standing height	56.7 ± 0.2	2.2	58.8 ± 0.3	2.6	61.4 ± 0.3	2.8	64.5 ± 0.3	3.2	67.0 ± 0.3	3.2
Sitting height	29.4 ± 0.1	1.2	30.3 ± 0.1	1.3	31.6 ± 0.2	1.6	33.2 ± 0.2	1.9	34.5 ± 0.2	1.9
Weight	78.0 ± 1.2	11.3	86.7 ± 1.4	13.1	97.3 ± 1.7	15.8	108.8 ± 1.8	17.1	121.2 ± 2.0	18.5
Ossification r.	.741 ± .010	.096	.836 ± .010	.094	.943 ± .008	.076	1.031 ± .006	.055	1.087 ± .008	.071
Chest girth . .	26.1 ± 0.2	1.4	27.0 ± 0.2	1.4	27.7 ± 0.2	1.8	29.3 ± 0.2	2.0	30.7 ± 0.2	2.2
Lung capacity .	127.0 ± 2.2	20.3	141.8 ± 2.4	21.8	159.3 ± 2.8	25.8	186.5 ± 3.6	33.7	212.4 ± 4.0	36.9
Group V: Thirty-two Boys Measured from the 12th through the 16th Birthdays										
Function	12		13		14		15		16	
Psychological .	172.0 ± 4.3	35.7	192.2 ± 3.8	31.9	208.8 ± 4.0	33.3	224.1 ± 3.5	29.6	238.2 ± 3.7	30.7
Standing height	59.4 ± 0.3	2.8	61.9 ± 0.4	3.3	64.7 ± 0.4	3.7	67.2 ± 0.4	3.4	69.1 ± 0.4	3.0
Sitting height	30.5 ± 0.2	1.4	31.7 ± 0.2	1.8	32.1 ± 0.3	2.1	34.6 ± 0.2	2.0	35.6 ± 0.2	1.9
Weight	87.3 ± 1.8	14.8	97.2 ± 2.2	18.1	108.7 ± 2.4	20.1	121.6 ± 2.5	21.1	132.7 ± 2.4	20.1
Ossification r.	.848 ± .012	.098	.937 ± .009	.079	1.023 ± .008	.064	1.075 ± .007	.062	1.121 ± .007	.057
Chest girth . .	27.0 ± 0.2	2.0	28.1 ± 0.3	2.3	29.1 ± 0.3	2.3	30.7 ± 0.3	2.4	32.1 ± 0.3	2.3
Lung capacity .	143.8 ± 2.9	24.4	161.8 ± 4.7	39.7	185.4 ± 4.9	41.5	214.8 ± 6.4	53.4	236.5 ± 4.9	40.9
Group VI: Forty Boys Measured from the 13th through the 17th Birthdays										
Function	13		14		15		16		17	
Psychological .	185.4 ± 3.6	33.9	203.1 ± 3.7	34.6	218.4 ± 3.5	33.2	233.8 ± 3.5	33.2	247.7 ± 3.4	31.5
Standing height	61.2 ± 0.3	3.1	64.3 ± 0.4	3.6	66.8 ± 0.4	3.4	68.5 ± 0.3	2.9	69.3 ± 0.3	2.6
Sitting height	31.5 ± 0.2	1.6	33.0 ± 0.2	2.1	34.3 ± 0.2	2.1	35.4 ± 0.2	2.0	36.2 ± 0.1	1.4
Weight	97.8 ± 1.9	17.9	109.7 ± 1.9	18.2	122.6 ± 2.2	20.2	132.9 ± 2.1	20.0	139.3 ± 2.1	19.4
Ossification r.	.933 ± .009	.083	1.018 ± .006	.060	1.076 ± .007	.063	1.115 ± .007	.063	1.159 ± .007	.065
Chest girth . .	28.3 ± 0.2	2.1	29.7 ± 0.2	2.2	31.0 ± 0.2	2.2	32.1 ± 0.2	1.9	33.0 ± 0.2	1.9
Lung capacity .	161.0 ± 2.7	25.1	189.1 ± 3.9	37.0	210.4 ± 4.2	39.4	237.3 ± 4.8	43.1	253.0 ± 4.1	38.8

TABLE IV

RATIO OF INCREMENT DURING EACH BIRTHDAY INTERVAL TO INCREMENT DURING THE TOTAL PERIOD OF MEASUREMENT. DATA FOR SIX GROUPS OF GIRLS, EACH GROUP MEASURED FOR FIVE SUCCESSIVE BIRTHDAYS*

Group I: Fifteen Girls Measured from the 8th through the 12th Birthdays				
Function measured	Percentage of four-year gain for each birthday interval			
	8-9	9-10	10-11	11-12
Psychological	11.8	25.8	33.7	28.7
Standing height	24.2	25.1	25.6	25.1
Sitting height	26.2	31.2	23.9	18.7
Weight	22.2	22.2	25.1	30.4
Ossification ratio	25.9	23.3	26.4	24.4
Chest girth	24.9	33.1	24.9	17.1
Group II: Seventeen Girls Measured from the 9th through the 13th Birthdays				
Function measured	9-10	10-11	11-12	12-13
Psychological	28.2	23.0	23.9	24.9
Standing height	23.1	25.3	26.8	24.9
Sitting height	19.4	25.7	28.0	26.9
Weight	17.7	28.2	28.0	26.1
Ossification ratio	31.2	33.5	18.5	16.8
Chest girth	29.0	30.6	23.6	16.8
Group III: Twenty-one Girls Measured from the 10th through the 14th Birthdays				
Function measured	10-11	11-12	12-13	13-14
Psychological	31.1	21.1	23.8	24.0
Standing height	28.5	28.9	26.6	16.0
Sitting height	25.2	29.5	26.7	18.6
Weight	23.1	30.5	23.5	22.9
Ossification ratio	35.6	28.0	21.9	14.5
Chest girth	26.1	34.3	20.8	18.8
Group IV: Twenty-nine Girls Measured from the 11th through the 15th Birthdays				
Function measured	11-12	12-13	13-14	14-15
Psychological	28.3	30.4	26.5	14.9
Standing height	34.5	32.1	23.0	10.3
Sitting height	29.3	33.3	23.4	13.9
Weight	29.7	28.6	25.8	15.9
Ossification ratio	40.7	24.4	18.4	16.5
Chest girth	36.0	35.7	20.7	7.6
Group V: Twenty-six Girls Measured from the 12th through the 16th Birthdays				
Function measured	12-13	13-14	14-15	15-16
Psychological	39.0	24.6	19.7	16.7
Standing height	41.7	30.5	16.1	11.6
Sitting height	37.3	31.9	20.3	10.5
Weight	38.0	28.5	22.2	11.3
Ossification ratio	36.5	32.2	20.7	10.6
Chest girth	57.1	20.3	20.9	1.7

TABLE IV (Continued)

Group VI: Thirty-four Girls Measured from the 13th through the 17th Birthdays				
Function measured	13-14	14-15	15-16	16-17
Psychological	27.6	16.6	32.9	22.8
Standing height	52.3	27.5	16.6	3.7
Sitting height	49.3	27.0	17.9	5.9
Weight	44.0	24.9	24.5	6.6
Ossification ratio	36.9	25.1	16.1	21.9
Chest girth	75.1	20.1	-5.5	10.3

*The percentages in Tables IV and V are based upon the totals from which the means in Tables II and III of the Appendix have been derived.

TABLE V

RATIO OF INCREMENT DURING EACH BIRTHDAY INTERVAL TO INCREMENT DURING THE TOTAL PERIOD OF MEASUREMENT. DATA FOR SIX GROUPS OF BOYS, EACH GROUP MEASURED FOR FIVE SUCCESSIVE BIRTHDAYS

Group I: Twelve Boys Measured from the 8th through the 12th Birthdays				
Function measured	Percentage of four-year gain for each birthday interval			
	8-9	9-10	10-11	11-12
Psychological	17.8	20.9	25.6	35.8
Standing height	26.5	25.5	25.0	22.9
Sitting height	27.9	36.4	15.8	20.0
Weight	23.3	24.1	30.0	22.6
Ossification ratio	21.8	25.6	24.7	27.9
Chest girth	27.5	27.3	26.0	19.3
Lung capacity	26.4	19.1	24.0	30.5
Group II: Twenty Boys Measured from the 9th through the 13th Birthdays				
Function measured	9-10	10-11	11-12	12-13
Psychological	22.5	25.0	28.0	24.6
Standing height	24.2	23.1	22.6	30.1
Sitting height	27.8	21.5	22.6	28.1
Weight	17.5	25.6	27.7	29.1
Ossification ratio	21.3	26.8	26.0	26.0
Chest girth	21.0	23.7	32.3	23.1
Lung capacity	25.0	19.8	24.3	31.0
Group III: Thirty-five Boys Measured from the 10th through the 14th Birthdays				
Function measured	10-11	11-12	12-13	13-14
Psychological	23.8	30.7	25.8	19.8
Standing height	20.5	21.3	26.5	31.8
Sitting height	19.5	21.3	26.2	33.0
Weight	19.4	22.1	28.2	30.3
Ossification ratio	22.6	26.9	27.2	23.3
Chest girth	11.3	24.9	23.5	40.3
Lung capacity	10.5	20.2	30.1	39.2

TABLE V (Continued)

Group IV: Thirty-nine Boys Measured from the 11th through the 15th Birthdays				
Function measured	11-12	12-13	13-14	14-15
Psychological	31.9	24.6	24.4	19.2
Standing height	20.1	25.1	29.9	24.9
Sitting height	16.6	25.7	32.3	25.4
Weight	20.2	24.5	26.6	28.7
Ossification ratio	27.5	30.9	25.4	16.2
Chest girth	20.7	15.5	34.5	29.3
Lung capacity	17.3	20.5	31.8	30.4
Group V: Thirty-two Boys Measured from the 12th through the 16th Birthdays				
Function measured	12-13	13-14	14-15	15-16
Psychological	30.5	25.1	23.1	21.3
Standing height	26.5	28.2	26.3	19.0
Sitting height	23.1	28.5	28.9	19.4
Weight	21.8	25.2	28.6	24.4
Ossification ratio	32.6	31.5	19.1	16.9
Chest girth	20.0	21.3	30.9	27.8
Lung capacity	19.0	24.8	31.1	25.0
Group VI: Forty Boys Measured from the 13th through the 17th Birthdays				
Function measured	13-14	14-15	15-16	16-17
Psychological	28.4	24.5	24.7	22.4
Standing height	37.2	30.9	21.2	10.7
Sitting height	31.4	27.4	24.3	16.8
Weight	28.5	31.3	24.8	15.4
Ossification ratio	37.2	25.6	18.1	19.2
Chest girth	29.2	28.9	23.9	18.0
Lung capacity	30.5	23.2	29.2	17.1

